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THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF PUBLIC SAFETY

BOARD OF FIRE PREVENTION REGULATIONS

MASSACHUSETTS ELECTRICAL CODE

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RULES AND REGULATIONS
GOVERNING THE
INSTALLATION, REPAIR AND MAINTENANCE
OF ELECTRICAL WIRING AND ELECTRICAL
FIXTURES USED FOR LIGHT, HEAT AND POWER
IN BUILDINGS AND STRUCTURES SUBJECT
TO THE PROVISIONS OF SECTIONS 3 TO 60,
CHAPTER 143, G. L., TER. ED., AS AMENDED

FORM FPR-11

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF PUBLIC SAFETY

BOARD OF FIRE PREVENTION REGULATIONS

MASSACHUSETTS ELECTRICAL CODE

In accordance with the provisions of G.L., C. 143, s. 3L, the Board of Fire Prevention Regulations herewith makes the following rules and regulations relative to the installation, repair and maintenance of electrical wiring and electrical fixtures used for light, heat and power purposes in buildings and structures subject to the provisions of G.L., C. 143, ss. 3 to 60, inclusive.

NOTE: These regulations are identical with the 1965 Edition of the NATIONAL ELECTRICAL CODE (NFPA No. 70, ASA C1-1965) except as follows:

1. Delete cover and pages 70-i through 70-x and pages 70-1 through 70-32. Substitute MASSACHUSETTS ELECTRICAL CODE INSERT #1 (cover through page 70-32).

2. Delete pages 65 through 80. Substitute MASSACHUSETTS ELECTRICAL CODE INSERT #2 (pages 65 through 80).

3. Amend the wording of the NATIONAL ELECTRICAL CODE by striking out the word "recommended" wherever it appears and substituting the word "shall"; and by striking out the words "NATIONAL ELECTRICAL CODE" wherever they appear and inserting the words "MASSACHUSETTS ELECTRICAL CODE".

4. Delete pages 70-425 through 70-432 and remove the back cover. Substitute MASSACHUSETTS ELECTRICAL CODE INSERT #3 (signature page).

5. Change the wording of the 1965 Edition of the NATIONAL ELECTRICAL CODE in accordance with the attached list entitled: "Form FPR-11, Massachusetts Electrical Code, Amendments to the National Electrical Code".

Rule 1. All installations, repairs and maintenance of electrical wiring and electrical fixtures used for light, heat and power purposes in buildings and structures subject to the provisions of Sections 3 to 60, Chapter 143, G.L. Ter. Ed., as amended, shall be reasonably safe to persons and property.

Rule 2. Conformity of installations, repairs and maintenance of electrical wiring and electrical fixtures used for light, heat and power with applicable regulations set forth in the code which is filed herewith with the Secretary of the Commonwealth shall be considered as complying with these requirements.

Mass Electrical Contractors
4-29-65

Rule 3. Additions or modifications to an existing installation shall be made in accordance with this code without bringing the remaining part of the installation to meet the requirements of this code.

Where an actual hazard exists, the owner of the property shall be notified in writing by the authority enforcing this code.

Note: All references in this code to other standards shall be considered as advisory and not mandatory.

With reference to the approval of specific items of equipment and materials contemplated by the code, it is pointed out that in order to avoid the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and to avoid the confusion which would result from conflicting reports as to the suitability of devices and materials examined for a given purpose, it is necessary that such examinations should be made under standard conditions, and the record made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determination through field inspections.

The approving authority may be guided in his approval by an indication that such equipment and materials have been tested and conform to suitable recognized industry standards.

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ARTICLE 90 — INTRODUCTION

90-1. Purpose.

(a) The purpose of this Code is the practical safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity for light. heat, power, radio, signalling and for other purposes.

(b) This Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use.

> Hazards often occur because of overloading of wiring systems by methods or usage not in conformity with the Code. This occurs because initial wiring did not provide for increases in use of electricity. For this reason it is recommended that the initial installation be adequate and that reasonable provisions for system changes be made as may be required for future increase in the use of electricity.

(c) This Code is not intended as a design specification nor an instruction manual for untrained persons.

90-2. Scope.

(a) Covered. It covers the electric conductors and equipment installed within or on public and private buildings and other premises, including yards, carnival and parking lots, and industrial substations; also the conductors that connect the installations to a supply of electricity, and other outside conductors adjacent to the premises; also mobile homes and travel trailers.

(b) Not Covered. It does not cover installations in mines, ships, railway cars, aircraft, automotive equipment, or the installations or equipment employed by a railway, electric or communication utility in the exercise of its function as a utility, and located outdoors or in buildings used exclusively for that purpose.

90-3. Code Arrangement. Chapters 1, 2, 3 and 4 of the Code are of general application. Chapters 5, 6 and 7 apply to installations which involve special occupancies, special equipment or other special conditions. These chapters are supplementary to, or amendatory of, the general rules, and the latter apply under such circumstances except as so amended for the particular conditions. Chapter 8 governs installations of communication systems, and is independent of the preceding Chapters except as they may be specifically referred to. Some tables and examples are included in Chapter 9.

90-4 Definitions. Article 100 contains definitions of a number of terms that are used in two or more Articles. In general, terms used only in a single Article are defined in the Article concerned. For electrical terms not defined in the Code, refer to the American Standard Definitions of Electrical Terms, ASA C-42.

90-5. Fundamental Rules. Throughout the Code are paragraphs which state only fundamentals or objectives of safeguarding. These are followed by paragraphs setting forth the recognized methods and detail by which the purpose and intent of the fundamental may be satisfied. Accordingly, when employed, the rules stating a fundamental only will appear as the first paragraph of an Article or Section.

90-6.

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90--7. Enforcement.

This code shall be used by the authority enforcing the code. The administrative authority supervising such enforcement of the code shall have the responsibility for making interpretations of the rules and shall accept approved or labeled equipment and materials suitable for the purpose for which they are to be used. He may decide on the approval of unlisted equipment and may grant special permission contemplated in a number of the rules.

90-8. Examination of Equipment for Safety. For approval of specific items of equipment and materials covered by the Code, examinations for safety should be made under standard conditions, and the record made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determination through field inspections. This avoids the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and the confusion that would result from conflicting reports as to the suitability of devices and materials examined for a given purpose.

90-9. Wiring Planning.

(a) Electrical engineers and others when drawing plans and specifications shall make provision for ample raceways for wiring, spaces for equipment, and allowances for future increases in the use of electricity. In laying out an installation for constant-potential systems, provision shall be made for distribution centers located in easily accessible places for convenience and safety of operation.

(b) It is elsewhere provided in this Code that the number of wires and circuits confined in a single enclosure be varyingly restricted. Electrical engineers and others who are planning installations shall provide similar restrictions wherever practicable, to the end that the effects of breakdowns from short-circuits or grounds, even though resulting fire and similar damage are confined to wires, their insulation and enclosures, may not involve entire services to premises nor interruptions of essential and independent services.

90-10. Revisions. It is customary to revise this Code periodically to conform with developments in the art and the result of experience, and the latest edition of the Code should always be used.

Chapter 1. General

ARTICLE 100 — DEFINITIONS

General guides for this Article on Definitions include: (1) for simplicity, only definitions essential to the proper use of this Code are included; (2) only those terms used in two or more Articles are defined in full in Article 100, other definitions being defined in the individual Article where they apply; (3) in general, **MASSACHUSETTS ELECTRICAL CODE** definitions will be the same as definitions in the latest revision of ASA C-42, "Definitions of Electrical Terms," and are so identified by an asterisk*.

***Accessible:** (As applied to wiring methods.) Not permanently closed in by the structure or finish of the building; capable of being removed without disturbing the building structure or finish. (See "Concealed" and "Exposed.")

***Accessible:** (As applied to equipment.) Admitting close approach because not guarded by locked doors, elevation or other effective means. (See "Readily Accessible.")

Ampacity: Current-carrying capacity expressed in amperes.

Anesthetizing Location: See Section 517-1(b).

Appliance: An appliance is utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

Appliance — Fixed: An appliance which is fastened or otherwise secured at a specific location.

Appliance — Portable: An appliance which is actually moved or can easily be moved from one place to another in normal use.

Appliance — Stationary: An appliance which is not easily moved from one place to another in normal use.

Approved:

Acceptable to the authority enforcing this Code. The approval of any equipment, materials and appliances will be based on its compliance with accepted principles of recognized engineering practice.

***Askarel:** A synthetic nonflammable insulating liquid which, when decomposed by the electric arc, evolves only nonflammable gaseous mixtures.

***Attachment Plug (Plug Cap) (Cap):** An attachment plug is a device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

***Automatic:** Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration. (See "Nonautomatic.")

Block (City, Town, or Village): See Section 800-2.

*__Branch Circuit:__ A branch circuit is that portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

A device not approved for branch circuit protection such as a thermal cutout or motor overload protective device is not considered as the overcurrent device protecting the circuit.

*__Branch Circuit—Appliance:__ An appliance branch circuit is a circuit supplying energy to one or more outlets to which appliances are to be connected; such circuits to have no permanently connected lighting fixtures not a part of an appliance.

Branch Circuit — General Purpose: A branch circuit that supplies a number of outlets for lighting and appliances.

Branch Circuit — Individual: A branch circuit that supplies only one utilization equipment.

Branch Circuit, Multiwire: A multiwire branch circuit is a circuit consisting of two or more ungrounded conductors having a potential difference between them, and an identified grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and which is connected to the neutral conductor of the system.

> BUILDING, a combination of any materials, whether portable or fixed, having a roof, to form a structure for the shelter of persons, animals or property. For the purpose of this definition "roof" shall include an awning or any similar covering, whether or not permanent in nature. The word "building" shall be construed where the context requires as though followed by the words "or part or parts thereof".

*__Cabinet:__ An enclosure designed either for surface or flush mounting, and provided with a frame, mat or trim in which swinging doors are hung.

Cell (As Applied to Raceways): See Section 356-1 and 358-1.

Circuit Breaker: A device designed to open and close a circuit by nonautomatic means, and to open the circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating.

Communication Circuit: See Section 800-1.

*__Concealed:__ Rendered inaccessible by the structure or finish of. the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them.

Conductor:

BARE: A bare conductor is one having no covering or insulation whatsoever. (See "Conductor, Covered.")

COVERED: A covered.conductor is one having one or more layers of nonconducting materials that are not recognized as insulation under the Code. (See "Conductor, Bare.")

*__Connector, Pressure (Solderless):__ A pressure wire connector is a device which establishes the connection between two or more conductors or between one or more conductors and a terminal by means of mechanical pressure and without the use of solder.

Continuous Load: A load where the maximum current is expected to continue for three hours or more.

Control Circuit: See Section 430-71.

Controller: A device, or group of devices, which serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. See also Section 430-81(a).

Cooking Unit, Counter-Mounted: An assembly of one or more domestic surface heating elements for cooking purposes designed for flush mounting in, or supported by, a counter, and which assembly is complete with inherent or separately mountable controls and internal wiring. (See "Oven, Wall-Mounted.")

Current Limiting Overcurrent Protective Device: (See Section 240-27.)

***Cutout Box:** An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "Cabinet.")

***Demand Factor:** The demand factor of any system, or part of a system, is the ratio of the maximum demand of the system, or part of a system, to the total connected load of the system, or of the part of the system under consideration.

Device: A unit of an electrical system which is intended to carry but not utilize electric energy.

Disconnecting Means: A device, or group of devices, or other means whereby the conductors of a circuit can be disconnected from their source of supply.

Dry: (See "Location — Dry.")

Dust-Ignition-Proof: See Section 502-1.

***Dustproof:** So constructed or protected that dust will not interfere with its successful operation.

***Dust-tight:** So constructed that dust will not enter the enclosing case.

Duty:

*CONTINUOUS: Continuous duty is a requirement of service that demands operation at a substantially constant load for an indefinitely long time.

*INTERMITTENT: Intermittent duty is a requirement of service that demands operation for alternate intervals of (1) load and no load; or (2) load and rest; or (3) load, no load and rest.

*PERIODIC: Periodic duty is a type of intermittent duty in which the load conditions are regularly recurrent.

*SHORT TIME: Short time duty is a requirement of service that demands operation at a substantially constant load for a short and definitely specified time.

*VARYING: Varying duty is a requirement of service that demands operations at loads, and for intervals of time, both of which may be subject to wide variation.

See Table 430-22 (a—Exception) for illustrations of various types of duty.

Duty Cycle (Welding): See Section 630-31(c).

***Electric Sign:** A fixed or portable, self-contained electrically illuminated appliance with words or symbols designed to convey information or attract attention.

***Enclosed:** Surrounded by a case which will prevent a person from accidentally contacting live parts.

Equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus and the like used as a part of, or in connection with, an electrical installation.

*** Explosion-proof Apparatus:** Apparatus enclosed in a case which is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

Exposed: (As applied to live parts.) Exposed means that a live part can be inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated or insulated. (See "Accessible" and "Concealed.")

***Exposed:** (As applied to wiring method.) Exposed means not concealed.

***Externally Operable:** Externally operable means capable of being operated without exposing the operator to contact with live parts.

This term is applied to equipment, such as a switch, that is enclosed in a case or cabinet.

Feeder: A feeder is the circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the branch circuit overcurrent device.

Fitting: An accessory such as a locknut, bushing or other part of a wiring system which is intended primarily to perform a mechanical rather than an electrical function.

Garage: A building or portion of a building in which one or more self-propelled vehicles carrying volatile, flammable liquid for fuel or power are kept for use, sale, storage, rental, repair, exhibition or demonstrating purposes, and all that portion of a building which is on or below the floor or floors in which such vehicles are kept and which is not separated therefrom by suitable cutoffs.

Ground: A ground is a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and earth, or to some conducting body which serves in place of the earth.

Grounded: Grounded means connected to earth or to some conducting body which serves in place of the earth.

Grounded (Effectively Grounded Communication System): See Section 800-2(d).

Grounded Conductor: A conductor which is intentionally grounded, either solidly or through a current limiting device.

Grounding Conductor: A conductor used to connect an equipment, device or wiring system with a grounding electrode or electrodes.

Guarded: Covered, shielded, fenced, enclosed or otherwise protected, by means of suitable covers or casings, barriers, rails or screens, mats or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger.

Hazardous Locations: See Article 500.

Header: See Section 356-1.

Header Ducts: See Section 358-1.

Hoistway: Any shaftway, hatchway, wall hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified: Identified, as used in this Code in reference to a conductor or its terminal, means that such conductor or terminal is to be recognized as grounded. See Article 200.

***Isolated:** Isolated means that an object is not readily accessible to persons unless special means for access are used.

***Lighting Outlet:** An outlet intended for the direct connection of a lampholder, a lighting fixture or a pendant cord terminating in a lampholder.

Location:

DAMP LOCATION: A location subject to a moderate degree of moisture, such as some basements, some barns, some cold storage warehouses, and the like.

DRY LOCATION: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

WET LOCATION: A location subject to saturation with water or other liquids, such as locations exposed to weather, washrooms in garages, and like locations. Installations underground or in concrete slabs or masonry in direct contact with the earth shall be considered as wet locations.

Low-Energy Power Circuit: A circuit which is not a remote-control or signal circuit but which has the power supply limited in accordance with the requirements of Class 2 remote control circuits. See Article 725.

Such circuits include electric door openers and circuits used in the operation of coin operated phonographs.

Multioutlet Assembly: A type of surface or flush raceway designed to hold conductors and attachment plug receptacles, assembled in the field or at the factory.

***Nonautomatic:** Nonautomatic means that the implied action requires personal intervention for its control. (See "Automatic.")

As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

***Outlet:** A point on the wiring system at which current is taken to supply utilization equipment.

***Outline Lighting:** An arrangement of incandescent lamps or gaseous tubes to outline and call attention to certain features such as the shape of a building or the decoration of a window.

Oven, Wall-Mounted: A domestic oven for cooking purposes designed for mounting in or on a wall or other surface.

Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel; including buses, and with or without switches and/or automatic overcurrent protective devices for the control of light, heat or power circuits of small individual as well as aggregate capacity; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "Switchboard.")

Projector, Nonprofessional: See Section 540-30.

Projector, Professional: See Section 540-10.

Qualified Person: One familiar with the construction and operation of the apparatus and the hazards involved.

Raceway: Any channel for holding wires, cables or busbars, which is designed expressly for, and used solely for, this purpose.

Raceways may be of metal or insulating material and the term includes rigid metal conduit, rigid nonmetallic conduit, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface metal raceways, structural raceways, wireways and busways.

***Raintight:** So constructed or protected that exposure to a beating rain will not result in the entrance of water.

***Readily Accessible:** Capable of being reached quickly, for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "Accessible.")

Receptacle (Convenience Outlet): A receptacle is a contact device installed at an outlet for the connection of an attachment plug and flexible cord.

***Receptacle Outlet:** An outlet where one or more receptacles are installed.

Refrigeration Compressor, Sealed (Hermetic Type): See Section 430-2.

Remote-Control Circuit: Any electrical circuit which controls any other circuit through a relay or an equivalent device.

Sealable Equipment: Equipment enclosed in a case or cabinet that is provided with means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Sealed (Hermetic Type) Refrigeration Compressor: A mechanical compressor consisting of a compressor and a motor, both of which are enclosed in the same sealed housing, with no external shaft nor shaft seals, the motor operating in the refrigerant atmosphere.

Service: The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

***Service Cable:** The service cable is the service conductors made up in the form of a cable.

Service Conductors: The supply conductors which extend from the street main, or from transformers to the service equipment of the premises supplied.

Service Drop: The overhead service conductors between the last pole or other aerial support and the first point of attachment to the building or other structure.

Service-Entrance Conductors, Overhead System: The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service-Entrance Conductors, Underground System: The service conductors between the terminals of the service equipment and the point of connection to the service lateral.

Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service Equipment: The necessary equipment, usually consisting of circuit-breaker or switch and fuses, and their accessories, located near point of entrance of supply conductors to a building and intended to constitute the main control and means of cutoff for the supply to that building.

Service Lateral: The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service entrance conductors in a terminal box inside or outside the building wall. Where there is no terminal box, the point of connection shall be considered to be the point of entrance of the service conductors into the building.

Service Raceway: The rigid metal conduit, electrical metallic tubing, or other raceway, that encloses the service entrance conductors.

Setting: (Of Circuit-breaker.) The value of the current at which it is set to trip.

Show-Window: A show-window is any window used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear, and whether or not it has a platform raised higher than the street floor level.

Sign: See "Electric Sign."

Signal Circuit: Any electrical circuit which supplies energy to an appliance which gives a recognizable signal.

Such circuits include circuits for door bells, buzzers, code-calling systems, signal lights, and the like.

Special Permission: The written consent of the authority enforcing this Code.

Switches:

*GENERAL USE SWITCH: A general use switch is a switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

GENERAL USE SNAP SWITCH: A form of general use switch so constructed that it can be installed in flush device boxes, or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this Code.

AC GENERAL USE SNAP SWITCH: A form of general use snap switch suitable only for use on alternating current circuits for controlling the following:

(a) Resistive and inductive loads (including electric discharge lamps) not exceeding the ampere rating at the voltage involved.

(b) Tungsten filament lamp loads not exceeding the ampere rating at 120 volts.

(c) Motor loads not exceeding 80 per cent of the ampere rating of the switches at the rated voltage.

All AC general use snap switches are marked "AC" in addition to their electrical rating.

AC-DC GENERAL USE SNAP SWITCH: A form of general use snap switch suitable for use on either direct or alternating current circuits for controlling the following:

(a) Resistive loads not exceeding the ampere rating at the voltage involved.

(b) Inductive loads not exceeding one-half the ampere rating at the voltage involved, except that switches having a marked horsepower rating are suitable for controlling motors not exceeding the horsepower rating of the switch at the voltage involved.

(c) Tungsten filament lamp loads not exceeding the ampere rating at 125 volts, when marked with the letter "T".

AC-DC general use snap switches are not generally marked AC-DC, but are always marked with their electrical rating.

*ISOLATING SWITCH: An isolating switch is a switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

MOTOR CIRCUIT SWITCH: A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switchboard: A large single panel, frame, or assembly of panels, on which are mounted, on the face or back or both, switches, overcurrent and other protective devices, buses and usually instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "Panelboard.")

Thermal Cutout: An overcurrent protective device which contains a heater element in addition to and affecting a renewable fusible member which opens the circuit. It is not designed to interrupt short circuit currents.

Thermal Protection: (As applied to motors.) The words, "Thermal Protection," appearing on the nameplate of a motor indicate that the motor is provided with a thermal protector.

Thermal Protector: (As applied to motors.) An inherent overheating protective device which is responsive to motor current and temperature and which, when properly applied to a motor, protects the motor against dangerous overheating due to overload or failure to start.

***Utilization Equipment:** Utilization equipment is equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purposes.

***Ventilated:** Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes or vapors.

Volatile Flammable Liquid: A flammable liquid having a flash point below 100°F. or whose temperature is above its flash point.

* **Voltage (of a circuit):** Voltage is the greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

On various systems such as 3-phase 4 wire, single phase 3 wire and 3 wire direct current, there may be various circuits of various voltages.

Voltage to Ground: In grounded circuits the voltage between the given conductor and that point or conductor of the circuit which is grounded; in ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight: So constructed that moisture will not enter the enclosing case.

***Weatherproof:** Weatherproof means so constructed or protected that exposure to the weather will not interfere with successful operation.

Raintight or watertight equipment may fulfill the requirements for "weatherproof." However, weather conditions vary and consideration should be given to conditions resulting from snow, ice, dust, or temperature extremes.

Welder, Electric.

RATED PRIMARY CURRENT: Section 630-31(c).
ACTUAL PRIMARY CURRENT: Section 630-31(c).

Wet: (See "Location — Wet.")

X-ray:

CONTINUOUS RATING: Section 660-4.
LONG TIME RATING: Section 660-4.
MOMENTARY RATING: Section 660-4.

ARTICLE 110 — GENERAL

110-1. Scope. This Article includes provisions applicable generally in installations of electric wiring and equipment.

110-2. Approval. The conductors and equipment required or permitted by this Code shall be acceptable only when approved. See definition of "Approved" in Article 100.

110-3. Mandatory and Advisory Rules. Mandatory rules of this Code are characterized by the use of the word, "shall." Advisory rules are characterized by the use of the word, "should," or are stated as recommendations of that which is advised but not required.

110-4. Examination of Equipment. Materials, devices, fittings, apparatus and appliances designed for use under this Code shall be judged chiefly with reference to the following considerations which also determine the classification by types, size, voltages, current capacities, and specific use.

(a) Suitability for installation and use in conformity with the provisions of this Code.

(b) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(c) Electrical insulation.

(d) Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service.

(e) Arcing effects.

110-5. Voltages. Throughout this Code the voltage considered shall be that at which the circuit operates, whether the current is supplied by a battery, generator, transformer, rectifier, or a thermopile.

110-6. Conductor Gages. Conductor sizes are given in American Wire Gage (AWG).

110-7. Conductors. Conductors normally used to carry current shall be of copper unless otherwise provided in this Code. Where conductor sizes are given in this Code, they shall apply to copper conductors. Where other materials are used, the size shall be changed accordingly.

For aluminum conductors, see Tables 310-14 and 310-15.

110-8. Wiring Methods. Only wiring methods recognized as suitable are included in this Code. The recognized methods of wiring may be installed in any type of building or occupancy except as otherwise provided in this Code.

110-9. Interrupting Capacity. Devices intended to break current shall have an interrupting capacity sufficient for the voltage employed and for the current which must be interrupted.

110-10. Circuit Impedance and Other Characteristics. The overcurrent protective devices, the total impedance and other characteristics of the circuit to be protected shall be so selected and coordinated as to permit the circuit protective devices used to clear a fault without the occurrence of extensive damage to the electrical components of the circuit. This fault may be assumed to be between two or more of the circuit conductors; or between any circuit conductor and the grounding conductor or enclosing metal raceway.

110-11. Deteriorating Agencies. Unless approved for the purpose, no conductors or equipment shall be located in damp or wet locations; where exposed to gases, fumes, vapors, liquids or other agents having a deteriorating effect on the conductors or equipment; nor where exposed to excessive temperatures.

110-12. Mechanical Execution of Work. Electrical equipment shall be installed in a neat and workmanlike manner.

110-13. Mounting of Equipment. Electrical equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster or similar materials shall not be depended on for security.

Whenever bare conductors for grounding purposes are used with non-metallic sheathed cable, they must be joined together in some manner approved by this Code. The "wrap around" or "back wrap" method is prohibited.

110-14. Connections to Terminals. Connection of conductors to terminal parts shall insure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set screw type), solder lugs or splices to flexible leads except that No. 8 or smaller solid conductors and No. 10 or smaller stranded conductors may be connected by means of clamps or screws with terminal plates having upturned lugs. Terminals for more than one conductor shall be of a type approved for the purpose.

Because of different characteristics of copper and aluminum, devices such as pressure connectors and soldering lugs shall be suitable for the material of the conductor and shall be properly installed and used. Materials such as solder, fluxes, inhibitors, and compounds, where employed, shall be suitable for the use and shall be of a type which will not adversely affect the conductors, installation, or equipment.

110-15. Splices. Conductors shall be spliced or joined with splicing devices approved for the use or by brazing, welding or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors.

110-16. Working Space about Electrical Equipment. Sufficient access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment.

(a) **Horizontal Dimensions.** Except as elsewhere required or permitted in this Code, the horizontal dimension of the working space in the direction of access to live parts, operating at not more than 600 volts, which are likely to require examination, adjustment, servicing or maintenance while alive, shall not be less than indicated in the following table. Distances are to be measured from the live parts if such are exposed or from the enclosure front or opening when such are enclosed.

Voltage to Ground	Minimum clear distance Condition: 1	2	3
0-150	2½ ft.	2½ ft.	3 ft.
151-600	2½	3½	4

Where the "Conditions" are as follows:

1. Exposed live part on one side and no live or grounded part on the other side of the working space or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not more than 300 volts shall not be considered live parts.

2. Exposed live parts on one side and grounded parts on the other side. Concrete, brick or tile walls shall be considered as grounded.

3. Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

Exception No. 1. Working space is not required in back of assemblies such as dead-front switchboards or control centers when there are no renewable or adjustable parts such as fuses or switches on the back and when all connections are accessible from other locations than the back.

Exception No. 2. Smaller spaces may be permitted by the authority having jurisdiction where it is judged that the particular arrangement of the installation will provide adequate accessibility.

(b) Clear Spaces. Working space required by this section shall not be used as a passageway or for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if adjacent to a passageway or general open space where other work is carried on, shall be suitably guarded.

(c) Access and Entrance to Working Space. At least one entrance of sufficient area shall be provided to give access to the working space about electrical equipment.

(d) Front Working Space. In all cases where there are live parts normally exposed on the front of switchboards or control centers, the working space in front of such boards or panels shall be not less than 3 feet.

(e) Illumination. Adequate illumination shall be provided for all working spaces about switchboards and control centers.

(f) Headroom. The minimum headroom of working spaces about switchboards or control centers where there are live parts exposed at any time, shall be 6¼ feet.

For higher voltages, see Article 710.

110-17. Guarding of Live Parts. (Not more than 600 Volts)

(a) Except as elsewhere required or permitted by this Code, live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures, or any of the following means:

(1) By location in a room, vault, or similar enclosure which is accessible only to qualified persons.

(2) By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(3) By a guard rail, provided the live parts operate at 600 volts or less and provided the location is such as to make contact with live parts unlikely.

(4) By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(5) By elevation at least 8 feet above the floor or other working surface.

(b) In locations where electrical equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(c) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

For motors see Sections 430-132 and 430-133. For additional requirements at voltages over 600 see Article 710.

110-18. Arcing Parts. Parts of electrical equipment which in ordinary operation produce arcs, sparks, flames or molten metal, shall be enclosed unless separated and isolated from all combustible material. For hazardous locations see Articles 500-517 inclusive. For motors see Section 430-14.

110-19. Light and Power from Railway Conductors. Circuits for lighting and power shall not be connected to any system containing trolley wires with a ground return, except in electric railway cars, car houses, power houses, or passenger and freight stations operated in connection with electric railways.

110-20. Insulation Resistance. All wiring shall be so installed that when completed the system will be free from short-circuits and from grounds other than as provided in Article 250. In order that a reasonable factor of safety may be provided, the following table of insulation resistances is suggested as a guide where the insulation is subjected to test:

(a) For circuits of No. 14 or No. 12 wire, 1,000,000 ohms. For circuits of No. 10 or larger conductor, a resistance based upon the allowable ampacities of conductors as fixed in Tables 310-12 through 310-15 as follows:

25 to 50 amperes, inclusive	250,000 ohms
51 to 100 amperes, inclusive	100,000 ohms
101 to 200 amperes, inclusive	50,000 ohms
201 to 400 amperes, inclusive	25,000 ohms
401 to 800 amperes, inclusive	12,000 ohms
Over 800 amperes	5,000 ohms

(b) The above values are to be determined with all switchboards, panelboards, fuseholders, switches, receptacles and overcurrent devices in place.

(c) Where climatic or other conditions are such that the wiring or equipment is exposed to excessive humidity, it may be necessary to modify the foregoing provisions.

110-21. Marking. The maker's name, trademark, or other identification symbol shall be placed on all electrical equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as are prescribed elsewhere in this Code.

110-22. Identification. Each disconnecting means required by this Code for motors and appliances, and each service, feeder or branch circuit at the point where it originates, shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking shall be of sufficient durability to withstand the environment involved.

Chapter 2. Wiring Design and Protection

ARTICLE 200 — USE AND IDENTIFICATION OF GROUNDED CONDUCTORS

200-1. Scope. This Article provides requirements for the use and identification of a grounded conductor in interior wiring systems. (See definitions of "grounded conductor" and "grounding conductor" in Article 100.)

200-2. General. All interior wiring systems shall have a grounded conductor which is continuously identified throughout the system except as follows:

Exception No. 1. A grounded conductor is not required in certain circuits or systems as provided in Sections 200-5, 250-3, 250-5, 250-6, 250-7, 250-8, 503-13, and 517-6.

Exception No. 2. Continuous identification throughout a length of a conductor between terminals is not required for certain conductors under Section 200-6(a and b).

200-3. Connection to Grounded System. No interior wiring shall be electrically connected to a supply system unless the latter contains, for any grounded conductor of the interior system, a corresponding conductor which is grounded.

Electrically connected implies connection capable of carrying current as distinguished from connection through electromagnetic induction.

200-4. Circuits Derived from Auto-Transformers. Branch circuits as described in Article 210 shall not be supplied through auto-transformers (transformers in which a part of the winding is common to both primary and secondary circuits) unless the system supplied has an identified grounded conductor which is solidly connected to a similar identified grounded conductor of the system supplying the auto-transformer.

200-5. Unidentified Circuits.

(a) Two wire branch circuits and AC circuits of two or more conductors may be tapped from the ungrounded conductors of circuits having identified grounded neutrals. Switching devices in each tapped circuit shall have a pole in each ungrounded conductor. These poles shall manually switch together where the switching devices serve as the disconnecting means required by Section 422-23.

Exception: For Motor Controllers see Section 430-84, and for heating equipment see Section 422-46.

(b) Polyphase circuits need not have one conductor grounded and identified, except as required by Section 250-5, but where one conductor is grounded it shall be identified.

(c) Other unidentified ungrounded systems or circuits may be used only by special permission.

200-6. Means of Identification of Grounded Conductors. Identification for grounded conductors shall be as follows:

(a) Insulated conductors of No. 6 or smaller, except conductors of Type MI cable, shall have an outer identification of white or natural gray color as specified in 310-2(g). The grounded conductors of Type MI cable shall be identified by distinctive marking at the terminals during the process of installation.

(b) Insulated conductors larger than No. 6, shall have an outer identification of white or natural gray color, or shall be identified by distinctive white marking at terminals during process of installation.

(c) Where, on a 4-wire delta-connected secondary, the midpoint of one phase is grounded to supply lighting and similar loads, that phase conductor having the higher voltage to ground shall be indicated by tagging or other effective means at any point where a connection is to be made if the neutral conductor is present.

200-7. Identified Conductor in Grounded Circuits Only. Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by Section 200-2, except under the following conditions, and then only where they are, in other respects, suitable for use as ungrounded conductors in the circuit:

Exception No. 1. Identified conductors, rendered permanently unidentified by painting or other effective means at each outlet where the conductors are visible and accessible, may be used as unidentified conductors.

The foregoing permits the use of two-wire cable having one black and one white conductor on two-wire circuits tapped from the outside legs of a three-wire system or any two conductors of a multiwire system where the identified conductor of the two-wire cable is rendered permanently unidentified at terminals.

Exception No. 2. Cable containing an identified conductor may be used for single-pole, three-way or four-way switch loops where the connections are so made that the unidentified conductor is the return conductor from the switch to the outlet.

This exception makes it unnecessary to paint the terminal of the identified conductor at the switch outlet.

Exception No. 3. A flexible cord, for connecting a portable appliance, having one conductor identified as required by Section 400-13 may be used even though there is no grounded conductor in the circuit supplying the outlet to which it is connected.

200-8. Connections to Screw-Shells. An identified conductor, where run to a screw-shell lampholder, shall be connected to the screw-shell.

200-9. Means of Identification of Terminals. The identification of terminals to which a grounded conductor is to be connected shall be by means of a metallic plated coating substantially white in color, such as nickel or zinc, or the terminals may be of material substantially white in color. The other terminals shall be of a readily distinguishable different color.

200-10. Identification of Terminals.

(a) Device Terminals. All devices provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification except as follows:

Exception No. 1. Marking may be omitted where the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

Exception No. 2. Single-pole Devices. Devices to the terminals of which only one side of the line is connected need not have terminals marked for identification.

Exception No. 3. Panelboards and Devices. The terminals of lighting panelboards and of devices having a normal current rating of over 30 amperes need not be marked for identification, except as required in Section 200-10(b) for polarized receptacles for attachment plugs and polarized attachment plugs.

(b) Plugs and Receptacles. Two-wire polarized receptacles for attachment plugs and polarized attachment plugs shall have the terminal intended for connection to the grounded conductor marked for identification.

Exception No. 1. Two-wire attachment plugs, unless of the polarity type, need not have their terminals marked for identification.

Exception No. 2. Three-wire and Four-wire Receptacles and Attachment Plugs. Three-wire and four-wire receptacles and attachment plugs, other than those of the grounding type which are rated within the limits outlined and required under Section 210-21(b), but on which one terminal may be used for the connection of either a grounding conductor or a grounded circuit conductor, shall have such a terminal marked to show other than a white or green finish.

(c) Screw-Shells. In the case of devices with screw-shells, the identified terminal shall be the one connected to the screw-shell. This does not apply to screw-shells which serve as fuseholders.

(d) Screw-Shell Devices with Leads. In the case of screw-shell devices with attached leads, the conductor attached to the screw-shell shall have white or natural gray finish. The outer finish of the other conductor shall be of a solid color that will not be confused with the white or natural-gray finish which is to identify the grounded conductor.

(e) Fixed Appliances. The terminals of fixed appliances need not be marked to indicate the proper connection to the grounded conductor unless a single-pole switch forms an integral part, then the terminal connected to the switch shall be the unidentified terminal.

(f) Portable Appliances. The terminals of portable appliances need not be marked for identification.

ARTICLE 210 — BRANCH CIRCUITS

210-1. Scope. The provisions of this Article shall apply to branch circuits supplying lighting or appliance loads or combinations of such loads. Where motors, or motor-operated appliances, are connected to any circuit supplying lighting or other appliance loads, the provisions of both this Article and Article 430 shall apply. Article 430 shall apply where branch circuit supplies only motor loads.

210-2. Specific Purpose Branch Circuit. The provisions applying to branch circuits referred to in the following table are exceptions to the provisions of this Article or are supplementary thereto, and shall apply to branch circuits supplying the loads referred to therein:

Busways	Section 364-8
Cranes and Hoists	Section 610-42
Elevators, Dumbwaiters and Escalators	Section 620-61
Infrared Industrial Heating Equipment	Section 422-11
Inductive and Dielectric Heat Generating Equipment	Article 665
Instruments	Section 384-22
Motion Picture Studios and Similar Locations	Article 530
Motors and Motor Controllers	Article 430
Organs	Section 650-6
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits	Article 725
Signs and Outline Lighting	Section 600-6
Sound Recording and Reproduction	Section 640-6
Space Heating; Panel and Embedded Types	Article 422
Systems over 600 Volts	Article 710
Systems under 50 Volts	Article 720
Theaters and Assembly Halls	Sections 520-41, 520-52, and 520-62
Welders	Article 630
X-ray Equipment	Section 660-3

210-3. Classifications. Branch circuits recognized by this Article shall be classified in accordance with the maximum permitted rating or setting of the overcurrent device, and the classification for other than individual branch circuits shall be 15, 20, 30, 40 and 50 amperes. When conductors of higher capacity are used for any reason, the rating or setting of the specified overcurrent device shall determine the circuit classification.

A. General Provisions

210-4. Multiwire Branch Circuits. Branch circuits recognized by this Article may be installed as multiwire circuits.

See Article 100 for Definition.

210-5. Color Code. Where installed in raceways, as aluminum sheathed cable, as open work, or as concealed knob-and-tube work, the conductors of multiwire branch circuits and two-wire branch circuits connected to the same system shall conform to the following color code. Three-wire circuits — one black, one white, one red; four-wire circuits — one black, one white, one red, one blue; five-wire circuits — one black, one white, one red, one blue, one yellow. Where more than one multiwire branch circuit is carried through a single raceway the ungrounded conductors of the additional circuit may be of colors other than those specified. All circuit conductors of the same color shall be connected to the same ungrounded feeder conductor throughout the installation.

Any conductor intended solely for grounding purposes shall be identified by a continuous green color or a continuous green color with a yellow stripe unless it be bare. Branch circuit conductors and equipment lead wires to which branch circuit conductors attach having a continuous green color or a continuous green color with a yellow stripe shall not be used for other than grounding purposes.

The above is not intended to prohibit the use of a conductor having a continuous green color or a continuous green color with a yellow stripe, insulation for internal wiring of equipment, except where such wiring serves as the lead wires to which the branch circuit conductors attach.

See Section 200-7 for use of white or natural gray for grounded or neutral conductors.

210-6. Voltage.

(a) Voltage to Ground. The voltage to ground on branch circuits supplying lampholders, fixtures, or standard receptacles of 15-ampere or less rating shall not exceed 150 volts, except as follows:

Exception No. 1. In industrial establishments or in stores where the conditions of maintenance and supervision assure that only competent individuals will service the lighting fixtures the voltage of branch circuits which supply only lighting fixtures that are equipped with mogul-base screw-shell lampholders or with lampholders of other types approved for the application, mounted not less than eight feet from the floor, which do not have switch control as an integral part of the fixture shall not exceed 300 volts to ground;

Exception No. 2. In industrial establishments, office buildings, schools, stores, and public and commercial areas of other buildings, such as hotels or transportation terminals, the voltage of branch circuits which supply only the ballasts for electric discharge lamps mounted in permanently installed fixtures, by other than screw-shell type lampholders, which do not have manual switch control as an integral part of the fixture shall not exceed 300 volts to ground. Where screw-shell type lampholders are used for electric discharge lamps the fixtures shall be installed not less than eight feet from the floor.

Exception No. 3. For infrared industrial heating appliances as described in Section 422-11;

Exception No. 4. In railway properties as described in Section 110-19;

Exception No. 5. The branch circuits supplying the ballasts for electric discharge lamps mounted in permanently installed fixtures on poles for the illumination of areas such as highways, bridges, athletic fields, parking lots, at a height not less than 22 feet, or on other struc-

tures such as tunnels at a height not less than 18 feet, shall not exceed 500 volts between conductors when installed as provided in Section 730-7(a).

(b) Voltage Between Conductors — Dwellings. In dwelling occupancies, the voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances, shall not exceed 150 volts, except as follows:

Exception: The voltage between conductors may exceed 150 volts when supplying only:

(1) Permanently connected appliances,

(2) Portable appliances of more than 1,380 watts,

(3) Portable motor-operated appliances of ¼ horsepower or greater rating.

(c) Voltage Drop. The size of the conductors for branch circuits as defined in Article 100 should be such that the voltage drop would not exceed 3% to the farthest outlet for power, heating, lighting, or combinations thereof. Providing further that the maximum total voltage drop for feeders and branch circuits should not exceed 5% over all.

210-7. Grounding Receptacles. Receptacles and cord connectors equipped with grounding contacts shall have those contacts effectively grounded. The branch circuit or branch circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the receptacle or cord connector shall be connected. The metal armor of Type AC metal-clad cable, the sheath of aluminum sheathed cable, or a metallic raceway is acceptable as a grounding conductor. See Sections 210-21(b), 250-45 and 250-59.

Exception: For extensions only in existing installations which do not have a grounding conductor in the branch circuit, the grounding conductor of a grounding type receptacle outlet may be grounded to a grounded cold water pipe near the equipment.

210-8. Heavy-Duty Lampholders. Heavy-duty lampholders referred to in this Article shall include lampholders rated at not less than 750 watts.

Exception: Admedium lampholders rated at 660 watts shall be considered to be heavy duty type.

B. Specific Requirements

210-19. Conductors. Circuit conductors shall conform to the following:

(a) Ampacity. Shall have an ampacity of not less than the rating of the branch circuit and not less than the maximum load to be served.

(b) Minimum Size. Shall not be smaller than No. 8 for ranges of 8¾ kw or more rating, nor smaller than No. 14 for other loads.

(c) Exceptions:

Exception No. 1. Range Loads. See Note 5 of Table 220-5. Where the maximum demand of a range of 8¾ kw or more rating is computed according to Column A of Table 220-5, the neutral conductor of a three-wire branch circuit supplying a household electric range, a wall-

mounted oven or a counter-mounted cooking unit may be smaller than the ungrounded conductors but shall have an ampacity at least 70 per cent of the ampacity of the ungrounded conductors and shall not be smaller than No. 10.

Cable assemblies with the neutral conductor smaller than the ungrounded conductors shall be so marked.

Exception No. 2. Tap Conductors. Tap conductors may be of less capacity than the branch circuit rating provided no tap conductor is of less capacity than the load to be served and provided the rating is not less than 20 amperes for 40 or 50 ampere circuits or 15 amperes for circuits rated less than 40 amperes and only when these tap conductors supply either:

(a) Individual lampholders or fixtures with taps extending not longer than 18 inches beyond any portion of the lampholder or fixture, except as required in Section 410-65 (b-2); or,

(b) Individual outlets with taps not over 18 inches long; or,

(c) Infra-red lamp industrial heating appliances.

(d) Nonheating leads of snow and ice melting cables and mats.

Exception No. 3. Fixture Wires and Cords. Fixture wires and cords may be of smaller size, but not less than the size specified in Exception No. 3 of Section 240-5.

See Tables 400-9(b) and 402-4.

Exception No. 4. Outlet Devices. Outlet devices may have less carrying capacity than the branch circuit rating, but not less than the types and ratings specified in Sections 210-21(a-c).

Exception No. 5. Where tap conductors supply electric ranges, wall-mounted electric ovens and counter-mounted electric cooking units from 50 ampere branch circuits they shall be of suitable capacity for the load to be served, not less than 20 amperes in rating and no longer than necessary for servicing the appliance.

210-20. Overcurrent Protection. The rating or setting of overcurrent devices shall conform to the following:

(a) Rating. Shall not be in excess of the value specified in Section 240-5.

Exception: Tap Conductors and Fixture Wires. Tap conductors, fixture wire and cords as permitted in Section 210-19(c) may be considered as protected by the circuit overcurrent device.

(b) Single Appliance. Shall not exceed 150 per cent of the rating of the appliance, where the circuit supplies only a single appliance of 10-ampere or more rating.

(c) Continuous Loads. Where loads other than motor loads will constitute continuous loads see Sections 210-23(b), 220-2 and 240-2.

210-21. Outlet Devices. Outlet devices shall have a rating not less than the load to be served and shall conform to the following:

(a) Lampholders. Lampholders when connected to circuits having a rating of over 20 amperes shall be of the heavy-duty type.

(b) Receptacles. Receptacles installed on 15 ampere and 20 ampere branch-circuits shall be of the grounding type and they shall be installed in accordance with Section 210-7.

Grounding type receptacles which are of a type that reject non-grounding type attachment plugs or which are of the locking type may be used for specific purposes or in special locations.

When grounding type receptacles are used as replacements for existing non-grounding types a grounding conductor installed in accordance with Section 250-57 shall be provided. If it is impractical to reach a source of ground a non-grounding type receptacle shall be used. The installation of grounding type outlets shall not be used as a requirement that all portable equipment be of the grounded type. See Article 250 for requirements for the grounding of portables.

Receptacles required in Section 517-3(d) are considered as meeting the requirements of this Section.

When connected to circuits having two or more outlets, receptacles shall conform to the following:

15-amp. circuits	Not over 15-amp. rating
20-amp. circuits	20-amp. rating
30-amp. circuits	30-amp. rating
40-amp. circuits	40 or 50-amp. rating
50-amp. circuits	50-amp. rating

Receptacles connected to circuits having different voltages, frequencies or types of current (AC or DC) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable.

Grounding receptacles rated at 15 or 20 amperes and installed in circuits of less than 150 volts between conductors shall be approved for use only on potentials less than 150 volts. Grounding receptacles rated at 15 amperes and installed in circuits of 151 to 300 volts between conductors shall be approved for use only on potentials not less than 151 volts.

Receptacles rated at 15 amperes connected to 20 ampere branch circuits serving two or more outlets shall not supply a total load in excess of 12 amperes for portable appliances. Receptacles rated at 20 amperes connected to 20 ampere branch circuits serving two or more outlets shall not supply a total load in excess of 16 amperes for portable appliances.

See Tentative Interim Amendment No. 128 at back of book.

(c) Capacity of range receptacles may be based on single range loads as computed from Table 220-5.

210-22. Receptacle Outlets Required. Receptacle outlets shall be installed as follows:

(a) General. Where portable cords are used, except where the attachment of cords by other means is specifically permitted.

A cord connector that is supported by a permanently connected cord pendant is considered a receptacle outlet.

(b) Dwelling Type Occupancies.
In every kitchen, dining room, breakfast room, living room, parlor, library, den, sun room, recreation room and bedroom, receptacle outlet shall be installed so that the maximum distance between any two successive receptacle outlets in any usable wall space shall not exceed twelve feet. To determine the minimum number of receptacle outlets required, divide the total horizontal linear footage of the four walls by twelve. If, after dividing by twelve, the remaining distance is less than twelve feet but greater than six feet, another receptacle outlet must be added. Receptacle outlets in floor shall not be counted as part of the required number of receptacle outlets unless located within six feet of the nearest wall receptacle. The receptacle outlets shall be placed in practical locations.

(c) Guest rooms in hotels, motels, and similar occupancies shall have receptacles installed in accordance with Section 210-22(b).

210-23. Maximum Load. The maximum load shall conform to the following:

(a) Appliances Consisting of Motors and Other Loads. Where a circuit supplies only motor operated appliance loads, Article 430 shall apply. For other than a portable appliance, the branch circuit size shall be calculated on the basis of 125 per cent of motor load where the motor is larger than ⅛ hp plus the sum of the other loads.

(b) Other Loads. The total load shall not exceed the branch circuit rating, and shall not exceed 80 per cent of the rating when load will constitute a continuous load such as store lighting and similar loads. In computing the load of lighting units which employ ballasts, transformers or auto-transformers, the load shall be based on the total of the ampere rating of such units and not on the wattage of the lamps.

Exception No. 1. When the assembly including the overcurrent device protecting the branch circuit is approved for continuous operation at 100 per cent of its rating, the total load may equal the branch circuit rating.

Exception No. 2. Where branch circuits are derated in accordance with Note 8 of Tables 310-12 through 310-15 the derating factor for continuous loading shall not apply.

Exception No. 3. Range Loads. See Note 5 of Table 220-5.

210-24. Permissible Loads. Individual branch circuits may supply any loads. Branch circuits having two or more outlets may supply only loads as follows:

(a) 15- and 20-Ampere Branch Circuits. Lighting units and/or appliances. The rating of any one portable appliance shall not exceed 80 per cent of the branch circuit rating. The total rating of fixed appliances shall not exceed 50 per cent of the branch circuit rating when lighting units or portable appliances are also supplied.

(b) 30-Ampere Branch Circuits. Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or appliances in any occupancy. The rating of any one portable appliance shall not exceed 24 amperes.

(c) 40-Ampere Branch Circuits. Fixed or stationary cooking appliances or fixed water heaters; or clothes dryers; in other than dwelling occupancies fixed lighting units with heavy-duty lampholders or infrared heating units.

(d) 50-Ampere Branch Circuits. Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or fixed cooking appliances; or infra-red lamp industrial heating appliances.

The term "fixed" as used in this Section recognizes cord connections where otherwise permitted.

Fixed outdoor electric snow melting and deicing installations may be supplied by any of the branch circuits described herein provided the circuit supplies no other load.

210-25. Table of Requirements. The requirements for circuits having two or more outlets [other than the receptacle circuits of Section 220-3(b)] as specifically provided for above are summarized in Table 210-25.

Table 210-25
Branch Circuit Requirements

(Type FEP, FEPB, R, RW, RU, RUW, RH-RW, SA, T, TW, RH, RUH, RHW, RHH, THHN, THW, and THWN conductors in raceway or cable.)

CIRCUIT RATING	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
CONDUCTORS: (Min. Size)					
Circuit Wires*	14	12	10	8	6
Taps	14	14	14	12	12
Fixture Wires and Cords	Refer to Section 240-5, Exception No. 3				
OVERCURRENT PROTECTION	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
OUTLET DEVICES:					
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty	Heavy Duty
Receptacle Rating	15 Max. Amp.	15 or 20 Amp.	30 Amp.	40 and 50 Amp.	50 Amp.
MAXIMUM LOAD	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
PERMISSIBLE LOAD	Refer to Section 210-24(a)	Refer to Section 210-24(a)	Refer to Section 210-24(b)	Refer to Section 210-24(c)	Refer to Section 210-24(d)

* These ampacities are for copper conductors where derating is not required. See Tables 310-12 through 310-15.

ARTICLE 215 — FEEDERS

215-1. Scope. This Article deals with installation requirements for, and, the size of conductors in the feeders needed to supply power to branch circuits and, the loads as calculated under Article 220.

215-2. Conductor Size. Feeder conductors shall have a current rating not smaller than the feeder load as determined by Section 220-4. A 2-wire feeder supplying two or more 2-wire branch circuits, or a 3-wire feeder supplying more than two 2-wire branch circuits, or two or more 3-wire branch circuits, shall be not smaller than No. 10. Where a feeder carries the total current supplied by the service-entrance conductors, such feeder, for services of No. 6 and smaller, shall be of the same size as the service-entrance conductors.

Where at any time it is found that feeder conductors are, or will be, overloaded, the feeder conductors shall be increased in capacity to accommodate the actual load served.

See Examples Nos. 1 to 7 of Chapter 9.

215-3. Voltage Drop. The size of the conductors for feeders should be such that the voltage drop for the load as computed by Section 220-4 would not be more than 3% for power, heating or lighting loads or combinations thereof. Providing further that the maximum total voltage drop for conductors for feeders and branch circuits should not exceed 5% over all.

215-4. Overcurrent Protection. Feeders shall be protected against overcurrent in accordance with the provisions of Article 240.

215-5. Common Neutral Feeder. A common neutral feeder may be employed for two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders. When in metal enclosures, all conductors of feeder circuits employing a common neutral feeder shall be contained within the same enclosure as provided in Section 300-20.

215-6. Diagram of Feeders. If required by the authority enforcing this Code, a diagram showing feeder details shall be supplied previous to installation. This diagram should show: Area in square feet; load (before applying demand-factors); demand-factors selected; computed load (after applying demand-factors); and the size of conductors.

215-7. Installation Requirements. Where a feeder supplies branch circuits in which grounding conductors are required, the feeder shall include or provide a grounding means to which the grounding conductor of the branch circuit shall be connected.

ARTICLE 220 — BRANCH CIRCUIT AND FEEDER CALCULATIONS

220-1. Scope. This Article provides the basis for calculating the expected branch circuit and feeder loads and for determining the number of branch circuits required.

220-2. Calculation of Branch Circuit Loads. The load for branch circuits shall be computed in accordance with the provisions of this Section.

Where in normal operation the maximum load will constitute a continuous load, such as store lighting and similar loads, the minimum unit loads specified in this Section shall be increased by 25 per cent.

Exception No. 1. Where branch circuits are derated in accordance with Note 8 of Tables 310-12 through 310-15 the unit loads are not required to be increased by 25 per cent.

Exception No. 2. When the assembly including the overcurrent devices protecting the branch circuits and feeders are approved for opera-

tion at 100 per cent of their rating the minimum unit loads need not be increased over those specified.

(a) General Lighting Load.

(1) In Listed Occupancies. In the occupancies listed in Table 220-2(a), a load of not less than the unit load specified shall be included for each square foot of floor area.

In determining the load on the "watts per square foot" basis, the floor area shall be computed from the outside dimensions of the building, apartment or area involved, and the number of floors; not including open porches, garages in connection with dwelling occupancies, nor unfinished spaces and unused spaces in dwellings unless adaptable for future use.

The unit values herein are based on minimum load conditions and 100 per cent power factor, and may not provide sufficient capacity for the installation contemplated.

In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load likely to be imposed and the capacity increased to insure safe operation.

Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

(2) In Other Occupancies. In other occupancies, a load of not less than the unit load specified in Section 220-2(b) shall be included for each outlet.

(b) Other Loads. For lighting other than general illumination and for appliances other than motors, a load of not less than the unit load specified below shall be included for each outlet.

*Outlets supplying specific appliances and other loads	Amp. rating of appliance
Outlets supplying heavy-duty lampholders	5 amperes
‡Other outlets	1½ amperes

*For motors, see Sections 430-22 and 430-24.

‡This provision shall not be applicable to receptacle outlets connected to the circuit specified in Section 220-3(b) nor to receptacle outlets provided for the connection of stationary equipment as provided for in Section 400-3.

(c) Exceptions. The minimum load for outlets specified in Section 220-2(b) shall be modified as follows:

Exception No. 1. Ranges. For household electric ranges, the branch circuit load may be computed in accordance with Table 220-5.

Exception No. 2. Show-Window Lighting. For show-window lighting a load of not less than 200 watts for each linear foot of show-window, measured horizontally along its base, may be allowed in lieu of the specified load per outlet.

Exception No. 3. Multioutlet Assemblies. Where fixed multioutlet assemblies are employed, each five feet or fraction thereof of each sep-

arate and continuous length shall be considered as one outlet of not less than 1½ ampere capacity; except in locations where a number of appliances are likely to be used simultaneously, when each one foot or fraction thereof shall be considered as an outlet of not less than 1½ amperes. The requirements of this Section are not applicable to dwellings or the guest rooms of hotels.

Exception No. 4. Telephone Exchanges. Shall be waived for manual switchboards and switching frames in telephone exchanges.

Table 220-2(a). General Lighting Loads by Occupancies

Type of Occupancy	Unit Load per Sq. Ft. (Watts)
Armories and Auditoriums	1
Banks	2
Barber Shops and Beauty Parlors	3
Churches	1
Clubs	2
Court Rooms	2
*Dwellings (Other Than Hotels)	3
Garages — Commercial (storage)	½
Hospitals	2
*Hotels and Motels, including apartment houses without provisions for cooking by tenants	2
Industrial Commercial (Loft) Buildings	2
Lodge Rooms	1½
Office Buildings	5
Restaurants	2
Schools	3
Stores	3
Warehouses Storage	¼
In any of the above occupancies except single-family dwellings and individual apartments of multifamily dwellings:	
Assembly Halls and Auditoriums	1
Halls, Corridors, Closets	½
Storage Spaces	¼

*All receptacle outlets of 15-ampere or less rating in single-family and multifamily dwellings and in guest rooms of hotels and motels [except those connected to the receptacle circuits specified in Section 220-3(b)] may be considered as outlets for general illumination, and no additional load need be included for such outlets.

The provisions of Section 220-2(b) shall apply to all other receptacle outlets.

(d) Existing Installations. Additions to existing installations shall conform to the following:

(1) Dwelling Occupancies. New circuits or extensions to existing circuits may be determined in accordance with Sections 220-2(a or b); except that portions of existing structures not previously wired, or additions to the building structure, either of which exceeds 500 square feet in area, shall be determined in accordance with Section 220-2(a).

(2) Other Than Dwelling Occupancies. When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of Section 220-2(a or b) shall apply.

220-3. Branch Circuits Required. Branch circuits shall be installed as follows:

(a) Lighting and Appliance Circuits. For lighting, and for appliances, including motor-operated appliances, not specifically provided for in Section 220-3(b), branch circuits shall be provided for a computed load not less than that determined by Section 220-2.

The number of circuits shall be not less than that determined from the total computed load and the capacity of circuits to be used. In every case the number shall be sufficient for the actual load to be served, and the branch circuit loads shall not exceed the maximum loads specified in Section 210-23.

Where the load is computed on a "watts per square foot" basis, the total load, in so far as practical, shall be evenly proportioned among the branch circuits according to their capacity.

When lighting units to be installed operate at other than 100 per cent power factor, see Section 210-23(b) for maximum ampere load permitted on branch circuits.

For general illumination in dwelling occupancies, not less than one branch circuit shall be installed for each 500 square feet of floor area in addition to the receptacle circuits called for in Section 220-3(b).

See Examples No. 1, 1a, 1b, 1c, and 4, Chapter 9.

(b) Receptacle Circuits, Dwelling Occupancies. For the small appliance load in kitchen, laundry, pantry, family room, dining room and breakfast room of dwelling occupancies, two or more 20 ampere branch circuits in addition to the branch circuits specified in Section 220-3(a) shall be provided for all receptacle outlets in these rooms, and such circuits shall have no other outlets.

Receptacle outlets supplied by at least two appliance receptacle branch circuits shall be installed in the kitchen.

Receptacle outlets installed solely for the support of and the power supply for electric clocks may be installed on lighting branch circuits.

A three wire 115/230 volt branch circuit is the equivalent of two 115 volt receptacle branch circuits.

(c) Other Circuits. For specific loads not otherwise provided for in Section 220-3(a or b), branch circuits shall be as required by other sections of the Code.

220-4. Calculation of Feeder Loads. The computed load of a feeder shall be not less than the sum of all branch circuit loads supplied by the feeder, as determined by Section 220-2, subject to the following provisions:

(a) General Lighting. The demand factors listed in Table 220-4(a) may be applied to that portion of the total branch circuit load computed for general illumination. These demand factors shall not be applied in determining the number of branch circuits for general illumination supplied by the feeders.

See Section 220-4(g and h).

The demand factors herein are based on minimum load conditions and 100 per cent power factor, and in specific instances may not provide sufficient capacity for the installation contemplated. In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load likely to be imposed and the capacity increased to insure safe operation. Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

Table 220-4(a). Calculation of Feeder Loads by Occupancies

Type of Occupancy	Portion of Lighting Load to which Demand Factor Applies (wattage)	Feeder Demand Factor
Dwellings — other than Hotels	First 3000 or less at	100%
	Next 3001 to 120,000·at	35%
	Remainder over 120,000 at	25%
*Hospitals	First 50,000 or less at	40%
	Remainder over 50,000 at	20%
*Hotels and Motels — including Apartment Houses without provision for cooking by tenants	First 20,000 or less at	50%
	Next 20,001 to 100,000 at	40%
	Remainder over 100,000 at	30%
Warehouses (Storage)	First 12,500 or less at	100%
	Remainder over 12,500 at	50%
All Others	Total Wattage	100%

* The demand factors of this Table shall not apply to the computed load of sub-feeders to areas in hospitals, hotels and motels where entire lighting is likely to be used at one time; as in operating rooms, ballrooms, or dining rooms.

(b) Show-Window Lighting. For show-window lighting, a load of not less than 200 watts shall be included for each linear foot of show-window measured horizontally along its base.

(c) Motors. For motors, a load computed according to the provisions of Sections 430-24, 430-25 and 430-26 shall be included.

(d) Neutral Feeder Load. The neutral feeder load shall be the maximum unbalance of the load determined by Section 220-4. The maximum unbalanced load shall be the maximum connected load between the neutral and any one ungrounded conductor; except that the load thus obtained shall be multiplied by 140 per cent for 5-wire, 2-phase systems. For a feeder supplying household electric ranges, wall-mounted ovens and counter-mounted cooking units, the maximum unbalanced load shall be considered as 70 per cent of the load on the ungrounded conductors, as determined in accordance with Table 220-5. For 3-wire DC or single-phase AC, 4-wire 3-phase and 5-wire 2-phase systems, a further demand-factor of 70 per cent may be applied to that portion of the unbalanced load in excess of 200 amperes. There shall be no reduction of the neutral capacity for that portion of the load which consists of electric discharge lighting.

See Examples 1, 1a, 1b, 1c, 2, 3, 4 and 5, Chapter 9.

(e) Fixed Electrical Space Heating. The computed load of a feeder supplying fixed electrical space heating equipment shall be the total connected load on all branch circuits.

Exception No. 1. Where reduced loading of the conductors results from units operating on duty-cycle, intermittently, or from all units not operating at one time, the authority enforcing this code may grant permission for feeder conductors to be of a capacity less than 100 per cent, provided the conductors are of sufficient capacity for the load so determined.

Exception No. 2. Section 220-4(e) does not apply when feeder capacity is calculated in accordance with optional method in Section 220-7 for one-family residences.

(f) Noncoincident Load. In adding the branch circuit loads to determine the feeder load, the smaller of two dissimilar loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

(g) Small Appliances. The computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than 1½ amperes per outlet, may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

Dwelling Occupancies

The requirements in following Sections 220-4 (h-k) apply to dwelling type occupancies and are supplemental to the preceding Sections 220-4(a-g).

(h) Small Appliances — Dwelling Occupancies. In single-family dwellings, in individual apartments of multifamily dwellings having provisions for cooking by tenants, and in each hotel suite having a serving pantry, a feeder load of not less than 1500 watts for each two-wire circuit installed as required by Section 220-3(b) shall be included for small appliances (portable appliances supplied from receptacles of 15 or 20 ampere rating) in pantry and breakfast-room, dining room, kitchen and laundry. Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 1500 watts for each two-wire circuit for small appliances. These loads may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

(i) Electric Ranges. The feeder load for household electric ranges and other cooking appliances, individually rated more than 1¾ kw, may be calculated in accordance with Table 220-5.

In order to provide for possible future installation of ranges of higher ratings, where ranges of less than 8¾ kw ratings or wall-mounted ovens and counter-mounted cooking units are to be installed, the feeder capacity shall be not less than the maximum demand value specified in Column A of Table 220-5.

Where a number of single-phase ranges are supplied by a 3-phase, 4-wire feeder, the current shall be computed on the basis of the demand of twice the maximum number of ranges connected between any two-phase wires.

See Example 7, Chapter 9.

(j) Fixed Electrical Appliances (Other than Ranges, Clothes Dryers, Air Conditioning Equipment or Space Heating Equipment). Where four or more fixed electrical appliances other than electric ranges, clothes dryers, air conditioning equipment or space heating equipment are connected to the same feeder in a single or multifamily dwelling, a demand factor of 75 per cent may be applied to the fixed appliance load.

(k) Space Heating and Air Cooling. In adding branch circuit loads for space heating and air cooling in dwelling occupancies, the smaller of the two loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

(l) Farm Buildings. Feeders supplying farm buildings (excluding dwellings) or loads consisting of two or more branch circuits shall have minimum capacity computed in accordance with the following table:

Table 220-4(l)

Demand Computation for Farm Buildings or Loads

Load in Amperes at 230 Volts	Per Cent of Connected Load
Loads expected to operate without diversity, but not less than 125% full load current of the largest motor and not less than first 60 Amperes.	100%
Next 60 Amperes of all other loads	50%
Remainder of other load	25%

NOTE 1: For services to farm dwellings, see Sections 220-2 through 220-7.

NOTE 2: For service at main point of delivery to farmstead, see Section 220-4(m).

(m) Farm Services.

(1) Service equipment and service entrance conductors for individual farm buildings (excluding dwellings) shall have minimum capacity computed in accordance with Section 220-4(l).

(2) Minimum capacity of service conductors and service equipment, if any, at the main point of delivery to farms (including dwellings) shall be determined in accordance with the following formula:

100 per cent of the largest demand computed in accordance with Section 220-4(l).

75 per cent of the second largest demand computed in accordance with Section 220-4(l).

65 per cent of the third largest demand computed in accordance with Section 220-4(l).

50 per cent of the demands of remaining loads computed in accordance with Section 220-4(l).

Note 1: Consider as a single computed demand the total of the computed demands of all buildings or loads having the same function.

Note 2: The demand of the farm dwelling, if included in the demands of this formula, should be computed in accordance with Note 1 of Table 220-4(1)

Table 220-5. Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units and Other Household Cooking Appliances Over 1¾ kw Rating

Column A to be used in all cases except as otherwise permitted in Note 4 below.

NUMBER OF APPLIANCES	Maximum Demand (See Notes)	Demand Factors (See Note 4)	
	COLUMN A (Not over 12 kw Rating)	COLUMN B (Less than 3½ kw Rating)	COLUMN C (3½ kw to 8¾ kw Rating)
1	8 kw	80%	80%
2	11 kw	75%	65%
3	14 kw	70%	55%
4	17 kw	66%	50%
5	20 kw	62%	45%
6	21 kw	59%	43%
7	22 kw	56%	40%
8	23 kw	53%	36%
9	24 kw	51%	35%
10	25 kw	49%	34%
11	26 kw	47%	32%
12	27 kw	45%	32%
13	28 kw	43%	32%
14	29 kw	41%	32%
15	30 kw	40%	32%
16	31 kw	39%	28%
17	32 kw	38%	28%
18	33 kw	37%	28%
19	34 kw	36%	28%
20	35 kw	35%	28%
21	36 kw	34%	26%
22	37 kw	33%	26%
23	38 kw	32%	26%
24	39 kw	31%	26%
25	40 kw	30%	26%
26-30	15 kw plus 1 kw for each range	30%	24%
31-40		30%	22%
41-50	25 kw plus ¾ kw for each range	30%	20%
51-60		30%	18%
61 & over		30%	16%

Note 1. Over 12 kw to 27 kw ranges all of same kw rating. For ranges, individually rated more than 12 kw but not more than 27 kw, the maximum demand in Column A shall be increased 5 per cent for each additional kw of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kw.

Note 2. Over 12 kw to 27 kw ranges *of unequal ratings.* For ranges individually rated more than 12 kw and of different ratings but none exceeding 27 kw an average value of rating shall be calculated by adding together the ratings of all ranges to obtain the total connected load (using 12 kw for any range rated less than 12 kw) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 per cent for each kw or major fraction thereof by which this average value exceeds 12 kw.

Note 3. This table does not apply to commercial ranges. The branch circuit load for a commercial range shall be the nameplate rating of the range.

Note 4. Over 1¾ kw to 8¾ kw. In lieu of the method provided in Column A, loads rated more than 1¾ kw but not more than 8¾ kw may be considered as the sum of the nameplate ratings of all the loads, multiplied by the demand factors specified in Columns B or C for the given number of loads.

Note 5. Branch Circuit Load. Branch circuit load for one range may be computed in accordance with Table 220-5. The branch circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room shall be computed by adding the nameplate ratings of the individual appliances and treating this total as equivalent to one range.

Table 220-6

Demand Factors for Household Electric Clothes Dryers

Number of Dryers	Demand Factor (per cent)
1	100
2	100
3	100
4	100
5	80
6	70
7	65
8	60
9	55
10	50
11-13	45
14-19	40
20-24	35
25-29	32.5
30-34	30
35-39	27.5
40 up	25

220-7. Optional Calculation for One-Family Residence. For a one-family residence served by a 115/230 volt, 3-wire, 100 ampere or larger service where the total load is supplied by one feeder or one set of service entrance conductors, the following percentages may be used in lieu of the method of determining feeder (and service) loads detailed in Section 220-4.

All other load shall include 1500 watts for each 20 ampere appliance outlet circuit [Section 220-3(b)]; lighting and portable appliances at 3 watts per square foot; all fixed appliances, (including four or more separately controlled space heating units [see Section 220-4(k)], ranges, wall-mounted ovens and counter-mounted cooking units) at nameplate rated load (kva for motors and other low power-factor loads).

See Examples 1(b) and 1(c) of Chapter 9.

Table 220-7
Optional Calculation for One-Family Residence

LOAD (in kw or kva)	Per Cent of Load
Air conditioning and cooling including heat pump compressors [see Section 220-4(k)]	100%
Central electrical space heating [see Section 220-4(k)]	100%
Less than four separately controlled electrical space heating units [see Section 220-4(k)]	100%
First 10 kw of all other load	100%
Remainder of other load	40%

ARTICLE 230 — SERVICES

A. General Requirements

230-1. Scope. The provisions of this Article shall apply to the conductors and equipment for control and protection of services — circuits that conduct electric power from the supply system or plant to the premises to be served.

For over 600 volts see Section 230-100.

230-2. Number of Services to a Building or Other Premises Served. In general, a building or other premises served shall be supplied through only one set of service conductors, except as follows:

Exception No. 1. Fire Pumps. Where a separate service is required for fire pumps.

Exception No. 2. Emergency Lighting. Where a separate service is required for emergency lighting and power purposes.

Exception No. 3. Multiple-Occupancy Buildings.

(a) By special permission, in multiple-occupancy buildings where there is no available space for service equipment accessible to all the occupants.

(b) Buildings of multiple occupancy may have two or more separate sets of service-entrance conductors which are tapped from one service drop or lateral, or two or more sub-sets of service-entrance conductors may be tapped from a single set of main service conductors. See Section 230-75 and Section 230-90 (a) Exception No. 4.

Exception No. 4. Capacity Requirements. Where capacity requirements make multiple services desirable.

Exception No. 5. Buildings of Large Area. By special permission, where more than one service is necessary due to the area over which a single building extends.

Exception No. 6. Different Characteristics or Classes of Use. Where additional services are required for different voltages, frequency, or phase, or different classes of use. Different classes of use could be because of needs for different characteristics, or because of rate schedule as in the case of controlled water heater service.

230-3. Supply to a Building from Another. No overhead service, no underground service and no service from an isolated plant shall supply one building from another, unless such buildings are under single occupancy or management. See Sections 230-45 and 230-76.

B. Insulation and Size of Service Conductors

230-4. Insulation of Service Conductors. Service conductors shall have an insulating covering which will normally withstand exposure to atmospheric and other conditions of use and which shall prevent any detrimental leakage of current to adjacent conductors, objects, or the ground.

Exception. Grounded Conductor. In the case of service conductors that have a nominal voltage to ground of not more than 300 volts, a grounded service conductor without an insulating covering may be installed.

For Service Drops — See Section 230-22.
For Service Entrance Conductors — See Section 230-40.
For Underground Services — See Section 230-30.
For Farmstead Service Conductors — See Section 220-4(m).

230-5. Size of Service Conductors. Service conductors shall have adequate ampacity to safely conduct the current for the loads supplied without a temperature rise detrimental to the insulating covering of the conductors, and shall have adequate mechanical strength.

Minimum sizes are given in the following references:
  For Service Drops — Section 230-23.
  For Service Entrance Conductors — Section 230-41.
  For Underground Service Conductors — Section 230-31.

C. Service Drops

230-21. Number of Drops. No building shall be supplied through more than one service drop, except for the purposes listed in Section 230-2.

230-22. Service Drop Conductors.

(a) In multiple-conductor cables, conductors shall be covered with rubber or thermoplastic, except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

(b) All open individual conductors shall be insulated or covered.

Conductors having extruded covering used for service drops have the same ampacities as covered conductors listed in Tables 310-13 and 310-15.

230-23 Minimum Size of Service Drop Conductors. Conductors shall be of sufficient size to carry the load and shall not be smaller than No. 8 copper or equivalent except for limited load as in Section 230-41, Exception No. 4, where they may be not smaller than No. 12 and shall then be of hard drawn copper or equivalent.

Conductors to a building from a pole on which a meter or disconnecting means is installed shall be considered as a service drop and installed accordingly.

230-24. Clearance of Service Drops. Service drop conductors shall not be readily accessible and when not in excess of 600 volts, shall conform to the following:

(a) Clearance Over Roof. Conductors shall have a clearance of not less than 8 ft. from the highest point of roofs over which they pass with the following exceptions:

Exception No. 1. Where the voltage between conductors does not exceed 300 and the roof has a slope of not less than 4 inches in 12 inches the clearance may be not less than 3 feet.

Exception No. 2. Service drop conductors of 300 volts or less which do not pass over other than a maximum of 4 feet of the overhang portion of the roof for the purpose of terminating at a (through-the-roof) service raceway or approved support may be maintained at a minimum of 18 inches from any portion of the roof over which they pass.

(b) Clearance from Ground. Conductors shall have a clearance of not less than 10 feet from the ground or from any platform or projection from which they might be reached. See Section 730-18.

(c) Clearance from Building Openings. Conductors shall have a clearance of not less than 36 inches from windows, doors, porches, fire escapes, or similar locations.

Conductors run above the top level of a window are considered out of reach from that window.

For clearances of conductors of over 600 volts see National Electrical Safety Code. (Available from Superintendent of Documents, Government Printing Office, Washington 25, D.C.)

230-25. Supports Over Buildings. Where practicable, conductors passing over a building shall be supported on structures which are independent of the building. Where necessary to attach conductors to roof they shall be supported on substantial structures.

230-26. Point of Attachment. The point of attachment of a service drop to a building or other structure shall be not less than 10 feet above finished grade and shall be at a height to permit a minimum clearance for service drop conductors of 10 feet above sidewalks and 18 feet above driveways, alleys and public roads. The attachment should not be more than 30 feet above ground unless a greater height is necessary for proper clearance. Where it is impractical to get the point of attachment high enough to obtain the above clearances, the clearance over residential driveways may be reduced, provided a clearance of 10 feet over sidewalks, 18 feet over alleys and public roads, and a minimum of 12 feet over residential driveways is obtained.

In the event a mast type riser is required to attain the required height, it shall be of such construction and so supported that it will withstand the strain imposed by the service drop. Raceway fittings shall be of a type approved for the purpose.

230-27. Means of Attachment. Multiple-conductor cables used for service drops shall be attached to buildings or other structures by fittings approved for the purpose. Open conductors shall be attached to noncombustible, nonabsorptive insulators securely attached to the building or other structure or by fittings approved for the purpose.

D. Underground Services

230-30. Insulation — Underground Service Conductors.

(a) Underground conductors up to the point of attachment to service equipment shall be covered with rubber, cambric, thermoplastic, paper or other approved insulating material, except:

Exception No. 1. Uninsulated grounded neutral conductors of aluminum or copper may be installed underground when part of an approved cable assembly.

Exception No. 2. Bare grounded neutral conductors of copper may be installed underground in duct or conduit.

(b) Insulated service conductors installed underground, or in concrete slabs or masonry in direct contact with earth, shall be lead-covered or of other types specially approved for the purpose.

230-31. Size of Underground Service Conductors.

(a) Size of Underground Service Lateral. Conductors shall be of sufficient size to carry the load and shall not be smaller than No. 8 copper or the equivalent except for limited load as in Section 230-41 Exception No. 4 the conductors shall not be smaller than No. 12 copper or equivalent.

(b) Size of Underground Service Entrance Conductors. Same as required for overhead service entrance conductors. See Section 230-41.

230-32. Protection Against Damage.

(a) In the Ground. Underground service conductors shall be protected against physical damage by being installed in duct, conduit, in cable of one or more conductors approved for the purpose, or by other approved means. See Sections 310-1(b), 310-5 and 310-6.

(b) On Poles. Where underground service conductors are carried up a pole the mechanical protection shall be installed to a point at least 8 feet above the ground. Such mechanical protection may be provided by the use of approved cable, pipe, or other approved means.

(c) Where Entering Building. Underground service conductors shall have mechanical protection in the form of rigid conduit, auxiliary gutters, the metal tape of an approved service cable, or other approved means. The mechanical protection shall extend to the enclosure for the service equipment unless the service switch is installed on a switchboard, in which case a bushing shall be provided which, except where lead-covered conductors are used, shall be of the insulating type.

230-33. Raceway Seal. Where a service raceway or duct enters from an underground distribution system, the end within the building shall be sealed with suitable compound so as to prevent the entrance of moisture or gases. Spare or unused ducts shall also be sealed.

230-34. Grounding Raceways and Cable Sheaths. See Section 230-63.

230-35. Termination at Service Equipment. See Section 230-42, Exception No. 3, and Section No. 230-53.

E. Service-Entrance Conductors

230-40. Insulation of Service-Entrance Conductors.

(a) Service-entrance conductors extending along the exterior of or entering buildings or other structures shall be rubber-covered or thermoplastic-covered if in raceways, or in cables approved for the purpose, except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

Where only on the exterior of the building or other structure the conductors shall be insulated or covered.

(b) Open individual conductors which enter the building or other structure shall be rubber-covered or thermoplastic-covered.

230-41. Size of Service-Entrance Conductors, Overhead System and Underground System.

Service-entrance conductors shall have sufficient ampacity to carry the load as determined by Article 220 and in accordance with Tables 310-12, 310-13, 310-14, 310-15. There shall be a minimum of 100 ampere 3-wire service for all individual residences except:

Exception No. 1. For installations consisting of not more than two 2-wire branch circuits they shall not be smaller than No. 8.

Exception No. 2. By special permission due to limitations of supply source or load requirements they shall not be smaller than No. 8.

Exception No. 3. For installations to supply only limited loads of a single branch circuit, such as small polyphase power, controlled water heaters and the like, they shall not be smaller than the conductors of the branch circuit and in no case smaller than No. 12.

Exception No. 4. The neutral conductor which shall have an ampacity in conformity with Section 220-4(d), but shall not be smaller than the ungrounded conductors when these are No. 8 or smaller.

230-42. Service-Entrance Conductors without Splice. Service-entrance conductors shall be without splice except as follows:

Exception No. 1. Clamped or bolted connections in a meter enclosure are permitted.

Exception No. 2. Taps to main service conductors are permitted as provided in Section 230-2 Exception No. 3(b) or to individual sets of service equipment as provided in Section 230-70(g).

Exception No. 3. A connection is permitted, when properly enclosed, where an underground service conductor enters a building and is to be extended to the service equipment or meter in another form of approved service raceway or service cable.

Exception No. 4. A connection is permitted where service conductors are extended from a service drop to an outside meter location and returned to connect to the service-entrance conductors of an existing installation.

230-43. Other Conductors in Service Raceway. Conductors other than service conductors, grounding conductors, or control conductors from time switches having overcurrent protection, shall not be installed in the same service raceway or service entrance cable.

F. Installation of Service-Entrance Conductors

230-44. Wiring Methods. Service-entrance conductors extending along the exterior, or entering buildings or other structures may be installed as separate conductors, in cables approved for the purpose, or enclosed in rigid conduit, or, for circuits not exceeding 600 volts, in electrical metallic tubing, wireways, auxiliary gutters, or as busways.

Service-entrance conductors should not be run within the hollow spaces of frame buildings unless provided with overcurrent protection at their outer end.

230-45. Conductor Considered Outside Building. Conductors placed under at least two inches of concrete beneath a building, or conductors within a building in conduit or duct and enclosed by concrete or brick not less than two inches thick shall be considered outside the building.

230-46. Mechanical Protection. Individual open conductors or cables other than approved service-entrance cables, shall not be installed within 8 feet of the ground or where exposed to physical damage. Service-entrance cables, where liable to contact with awnings, shutters, swinging signs, installed in exposed places in driveways, near coal chutes or otherwise exposed to physical damage, shall be of the protected type or be protected by conduit, electrical metallic tubing or other approved means.

230-47. Individual Open Conductors Exposed to Weather. Individual open conductors exposed to weather shall be supported on insulators, racks, brackets, or other means, placed at intervals not exceeding 9 feet and separating the conductors at least 6 inches from each other and 2 inches from the surface wired over; or at intervals not exceeding 15 feet if they maintain the conductors at least 12 inches apart. For 300 volts or less, conductors may have a separation of not less than 3 inches where supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over.

230-48. Individual Open Conductors Not Exposed to Weather. Individual open conductors not exposed to the weather may be supported on glass or porcelain knobs placed at intervals not exceeding 4½ feet and maintaining the conductors at least one inch from the surface wired over and a separation of at least 2½ inches between conductors.

230-49. Individual Conductors Entering Buildings. Individual conductors entering buildings shall pass inward and upward through slanting noncombustible, nonabsorptive insulating tubes, or shall enter through roof bushings, and shall conform to the provisions of Article 324. Drip loops shall be formed on the conductors before entering tubes.

230-50. Service Cables. Service cables of a type not approved for mounting in contact with a building shall have insulating supports at intervals not exceeding 15 feet, and maintaining a distance of at least 2 inches from the surface wired over. Service cables mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

230-51. Service Head. Service raceways shall be equipped with a raintight service head. Service cables, unless continuous from pole to service equipment or meter, shall be equipped with an approved raintight service head, or be formed in a gooseneck, taped and painted or taped with self-sealing weather-resistant thermoplastic. They shall be held securely in place by connection to service-drop conductors below the gooseneck or by a fitting approved for the purpose. Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop conductors below the level of the service head or the termination of service-entrance cable sheaths. Service drop conductors, and service entrance conductors, shall be so arranged that water will not enter service raceway and equipment. Where service heads are used, conductors of opposite polarity shall be brought out through separately bushed holes. Service heads and goosenecks in service entrance cable shall be located above the point of attachment of the service drop conductors.

Exception: Where building construction or location of service head or termination point of service drop conductors at the building is such as to be impractical for service head to be above the termination point of the service drop conductors, such service head may be located not more than twenty-four inches from the termination point of the service drop conductors and shall have a mechanical connector at the lowest point in the drip loop to prevent siphoning.

230-52. Enclosing Raceways Made Raintight. When rigid metal raceways are installed where exposed to weather the raceways shall be made raintight and arranged to drain.

230-53. Terminating Raceway at Service Equipment. Where conduit, electrical metallic tubing, or service cable is used for service conductors, the inner end shall enter a terminal box or cabinet, or be made up directly to an equivalent fitting, enclosing all live metal parts, except that where the service disconnecting means is mounted on a switchboard having exposed bus-bars on the back, the raceway may be equipped with a bushing which shall be of the insulating type unless lead-covered conductors are used.

230-54. Grounding Service Raceways and Cable Armor. See Section 230-63.

G. Service Equipment

230-60. Hazardous Locations. Service equipment installed in hazardous locations shall comply with the requirements of Articles 500 to 517 inclusive.

230-61. Service Equipment Grouped. Where supplied at the same side of the building by more than one overhead service drop or more than one set of underground service conductors, the service equipment, except for services as permitted in Section 230-2, shall be grouped and equipment marked to indicate the load it serves.

H. Grounding and Guarding

230-62. Guarding. Live parts of service equipment shall be enclosed so that they will not be exposed to accidental contact, unless mounted on a switchboard, panelboard or controller accessible to qualified persons only and located in a room or enclosure free from easily ignitible material. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

230-63. Grounding and Bonding. Service equipment shall be grounded as follows:

(a) Equipment. The enclosure for service equipment shall be grounded in the manner specified in Article 250, unless (1) the voltage does not exceed 150 volts to ground and such enclosures are (2) isolated from conducting surfaces, and (3) unexposed to contact by persons or materials that may also be in contact with other conducting surfaces.

(b) Raceways. Service raceways, and the metal sheath of service cables, shall be grounded. Conduit and metal pipe from underground supply shall be considered sufficiently grounded where containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

(c) Flexible Conduit. Where a service run of rigid metal raceway is interrupted by flexible metal conduit, the sections of rigid metal raceway thus interrupted shall be bonded together by a copper conductor not smaller than specified for grounding conductors in Table 250-94 (a), using clamps or other approved means. The conductor and bonding devices shall be protected from physical damage. Where the flexible conduit runs to the service cabinet, similar bonding shall be installed between the cabinet and the rigid raceway.

J. Disconnecting Means

230-70. General. (For multiple occupancy buildings see also Section 230-75.)

(a) Disconnection from Service Conductors. Means shall be provided for disconnecting all conductors in the building or other structure from the service entrance conductors.

(b) Location. The disconnecting means shall be located at a readily accessible point nearest to the entrance of the conductors, either inside or outside the building or other structure. See also Section 230-45 and Section 110-16.

(c) Approval. The disconnecting means shall be of a type approved for service equipment and for prevailing conditions.

(d) Types Permitted. The disconnecting means for ungrounded conductors shall consist of either:

(1) A manually operable switch or circuit-breaker equipped with a handle or other suitable operating means positively identified and marked for mechanical operation by hand.

(2) An electrically operated switch or circuit-breaker provided the switch or circuit-breaker can be opened by hand in event of a failure of the power supply and the open and closed positions are clearly indicated to the operator.

(e) Externally Operable. An enclosed service switch or circuit-breaker shall be externally operable. See definition Article 100.

Where the current of a single circuit, or group of circuits, is separately metered, as in apartment house installations, devices shall be installed in a convenient location to control each separately metered installation, such devices being enclosed and the switch or circuit breaker being externally operable.

(f) Indicating. The disconnecting means shall plainly indicate whether it is in the open or closed position.

(g) Switch and Circuit Breaker. It may consist of not more than six switches or six circuit breakers in a common enclosure, or in a group of separate enclosures. Two or three single pole switches or breakers, capable of individual operation, may be installed on multiwire circuits, one pole for each ungrounded conductor, as one multipole disconnect [where applicable, see Section 230-70(h)] provided they are equipped with "handle ties," "handles within 1/16 inch proximity," a "master handle," or "other means," making it practical to disconnect all conductors of the service with no more than six operations of the hand.

See Section 200-5 and Section 384-16(a).

(h) Simultaneous Openings. The disconnecting means shall simultaneously disconnect all ungrounded conductors, except for 3-wire direct-current or single-phase circuits or multiwire circuits that do not supply polyphase motors.

See Section 200-5(a).

(i) Disconnection of Grounded Conductor. Where the switch or circuit breaker does not interrupt the grounded conductor, other means shall be provided in the service cabinet or on the switchboard for disconnecting the grounded conductor from the interior wiring.

230-71. Rating of Service Equipment.

(a) The service disconnecting means shall have a rating not less than the load to be carried determined in accordance with Article 220. In general the service disconnecting means shall have a rating of not less than 60 amperes where a switch is used, and not less than 50 amperes where a circuit breaker is used, except:

Exception No. 1. For installations consisting of not more than two 2-wire branch circuits a service equipment of 30-ampere minimum rating may be used.

(b) Where multiple switches or circuit breakers are used in accordance with Section 230-70(g) the combined rating shall not be less than required for a single switch or breaker.

230-72. Connection to Terminals. The service conductors shall be attached to the disconnecting means by pressure connectors, clamps or other approved means, except that connections which depend upon solder shall not be used.

230-73. Connections Ahead of Disconnecting Means. Service fuses, meters, high-impedance shunt circuits (such as potential coils of meters, etc.), supply conductors for time switches, surge protective capacitors, instrument transformers, lightning arresters and circuits for emergency systems, fire pump equipment, fire and sprinkler alarms as provided in Section 230-94, may be connected on the supply side of the disconnecting means. Taps from service conductors to supply time switches, circuits for emergency lighting, etc., shall be installed in accordance with Section 230-44 and disconnecting means shall be installed as required in Section 230-70.

For detailed service provisions for fire alarm, sprinkler supervisory, or watchman systems, see appropriate Standards of the National Fire Protection Association.

230-74. Safeguarding Emergency Supply. Where an emergency supply is provided to feed the conductors controlled by the service disconnecting means, the disconnector shall be of a design that will open all ungrounded conductors from the usual supply before connection is made to the emergency supply, unless agreed upon arrangements have been made for parallel operation and suitable automatic control equipment provided. See Article 700.

230-75. Multiple Occupancy. In a multiple occupancy building, each occupant shall have access to his disconnecting means. A multiple occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the disconnecting means consisting of not more than six switches or six circuit breakers. Multiple occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with Section 230-2, Exception No. 3 and each such service may have not more than six switches or circuit breakers.

230-76. More Than One Building. In a property comprising more than one building under single management, the conductors supplying each building served shall be provided with a readily accessible means, within or adjacent to the building, of disconnecting all ungrounded conductors from the source of supply. In garages and outbuildings on residential property the disconnecting means may consist of a snap switch, suitable for use on branch circuits, including switch controls at more than one point.

K. Overcurrent Protection

230-90. Where Required. Each ungrounded service-entrance conductor shall have overcurrent protection.

(a) Ungrounded Conductor. Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor, having a rating or setting not higher than the allowable ampacity of the conductor, except as follows:

Exception No. 1. For motor-starting currents, ratings in conformity with Sections 430-52, 430-62, or 430-63 may be used.

Exception No. 2. Circuit breakers may have a rating or setting in conformity with Section 240–5, Exceptions No. 1 and 2, also Section 240-7; fuses shall conform to requirements of Section 240-6.

Exception No. 3. Not more than six circuit breakers or six sets of fuses may serve as the overcurrent device.

Exception No. 4. In a multiple occupancy building each occupant shall have access to his overcurrent protective devices. A multiple occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the overcurrent protection consisting of not more than six circuit breakers or six sets of fuses. Multiple occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy in accordance with Section 230-2, Exception No. 3(b) and each such service may have not more than six circuit breakers or six sets of fuses.

A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit. Single pole breakers may be grouped as in Section 230-70(g) as one multiple protective device.

(b) Not in Grounded Conductor. No overcurrent device shall be inserted in a grounded service conductor except a circuit breaker which simultaneously opens all conductors of the circuit.

(c) More Than One Building. In a property comprising more than one building under single management, the ungrounded conductors supplying each building served shall be protected by overcurrent devices, which may be located in the building served or in another building on the same property, provided they are accessible to the occupants of the building served.

230-91. Location. The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto, unless located at the outer end of the entrance.

230-92. Location of Branch-Circuit Overcurrent Devices. Where the service overcurrent devices are locked or sealed, or otherwise not readily accessible, branch-circuit overcurrent devices shall be installed on the load side, shall be mounted in an accessible location and shall be of lower rating than the service overcurrent device.

230-93. Protection of Specific Circuits. Where necessary to prevent tampering, an automatic overcurrent device protecting service conductors supplying only a specific load such as a water heater, may be locked or sealed where located so as to be accessible.

230-94. Relative Location of Overcurrent Device and Other Service Equipment. The overcurrent device shall protect all circuits and devices except as follows:

(a) The service switch may be placed on the supply side.

(b) High impedance shunt circuits (such as potential coils of meters, etc.), lightning arresters, surge protective capacitors, instrument transformers, may be connected and installed on the supply side of the service disconnecting means as permitted in Section 230-73.

(c) Circuits for emergency supply and time switches may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(d) Circuits used only for the operation of fire alarm, other protective signalling systems, or the supply to fire pump equipment may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(e) Meters for alternating current service not in excess of 600 volts, provided the service contains a grounded conductor and the cases and enclosures of such meters are grounded by connection to the grounded circuit conductor (see Section 250-61) or to a common system and equipment ground electrode (see Section 250-54); or meters for alternating current service not containing a grounded service conductor and not in excess of 300 volts.

L. Services Exceeding 600 Volts

230-100. Scope. Service conductors and equipment used on circuits exceeding 600 volts shall comply with the applicable provisions of the preceding sections of this Article and with the following Sections which are additions to or modifications of the preceding Sections.

Secondary conductors, not the primary conductors, are the service conductors to the building proper in the following cases:

1. Where step-down transformers are located outdoors.
2. Where step-down transformers are located in a separate building from the one served.
3. Where step-down transformers are located in the building served and in a transformer vault conforming to the requirements of Sections 450-41 to 450-48, and under the sole control of the supply company.

In all other cases, the primary conductors are the service conductors.

In no case will the provisions of this Article apply to equipment not directly connected to service conductors, and consequently will not apply to equipment in vaults under the sole control of the supply company.

230-101. Service-Entrance Conductors.

(a) Conductor Size. Service conductors shall be not smaller than No. 6 unless in cable. Conductors in cable shall be not smaller than No. 8.

(b) Wiring Methods. In locations accessible to other than qualified persons service-entrance conductors of more than 600 volts shall be installed in rigid conduit, or as multiple conductor cable approved for the purpose.

(c) Open Work. If open work is employed where not accessible to other than qualified persons, the service conductors shall be rigidly supported on glass, porcelain or other insulators approved for the purpose, which will keep them at least 8 inches apart, except at terminals of equipment. They shall be not less than 2 inches from the surfaces wired over and for voltages exceeding 2,500 not less than 3 inches.

(d) Supports. Service conductors and their supports, including insulators, shall have strength and stability sufficient to insure maintenance of adequate clearance with abnormal currents in case of short circuits.

(e) Guarding. Open wires shall be guarded where accessible to unqualified persons.

(f) Service Cable. Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors shall be protected from moisture and physical damage by a pothead or other approved means.

(g) Draining Raceways. Unless conductors specifically approved for the purpose are used, raceways embedded in masonry, or exposed to the weather, or in wet locations shall be arranged to drain.

(h) Over 15,000 Volts. Where the voltage exceeds 15,000 volts between conductors they shall enter either metal enclosed switchgear or a transformer vault conforming to the requirements of Section 450-41 to 450-48.

(i) Conductor Considered Outside Building. Conductors placed under at least two inches of concrete beneath a building, or conductors within a building in conduit or duct and enclosed by concrete or brick not less than two inches thick shall be considered outside the building.

230-102. Warning Signs. High voltage signs shall be posted where unauthorized persons might come in contact with live parts.

230-103. Disconnecting Means. The circuit-breaker or the alternatives for it specified in Section 230-106 will constitute the disconnecting means required by Section 230-70 and shall comply with Section 230-70(h). The disconnecting means shall be capable of being closed on a fault within the maximum interrupting rating of the overcurrent protection.

230-104. Isolating Switches. Isolating switches shall be provided as follows:

(a) Air-break isolating switches shall be installed between oil switches or air or oil circuit breakers used as service switches and the supply conductor, except where such equipment is mounted on removable truck panels or metal-enclosed switchgear units which cannot be opened unless the circuit is disconnected, and which, when removed from the normal operating position, automatically disconnect the circuit breaker or switch from all live parts.

(b) When the fuses used with nonautomatic oil switches in accordance with Section 230-106 are of a type that may be operated as a disconnect switch, they may serve as the isolating switch when they completely disconnect the oil switch and all service equipment from the source of supply.

(c) Air-break isolating switches shall be accessible to qualified attendants only. They shall be arranged so that a grounding connection on the load side can readily be made. Such grounding means need not be provided for duplicate isolating switches, if any, installed and maintained by the supply company.

230-105. Equipment in Secondaries. Where the primary service equipment supplies one or more transformers whose secondary windings connect to a single set of mains, and the primary load-interrupter switch or circuit-breaker is capable of being opened and closed from a point outside the transformer vault, the disconnecting means and overcurrent protection may be omitted from the secondary circuit provided the primary fuse or circuit-breaker is rated or set to protect the secondary circuit.

230-106. Overcurrent Protection. Overcurrent devices shall be provided in accordance with the following:

(a) In Vault or Consisting of Metal-Enclosed Switchgear. Where the service equipment is installed in a transformer vault meeting the provisions of Sections 450-41 to 450-48, or consists of metal-enclosed switchgear, the requirements for overcurrent protection and disconnecting means may be fulfilled by the following:

(1) A non-automatic oil switch, oil fuse cutout, air load-interrupter switch, or other approved switch, capable of interrupting the rated circuit load, and suitable fuses may be used.

(2) An automatic trip circuit-breaker of suitable current carrying and interrupting capacity with an overcurrent unit in each ungrounded conductor may be used.

(3) A switch capable of interrupting the no-load current of the transformer supplied through the switch and suitable fuses may be used, provided the switch is interlocked with a single switch or circuit breaker on the secondary circuit of the transformer so that the primary switch cannot be opened when the secondary circuit is closed.

(4) Vaults shall conform to the provisions of Sections 450-41 to 450-48.

(5) Metal-enclosed switchgear shall consist of a substantial metal structure and a sheet metal enclosure. Barriers between adjacent switchgear units and internal metal barriers shall be not less than ⅛ inch of metal or No. 11 U.S.S. gage. All other covers, panels and doors shall be not less than No. 14 U.S.S. gage. Where installed over a wood floor, suitable protection thereto shall be provided.

(b) Not in Vault or Not Consisting of Metal-enclosed Switchgear. Where the service equipment is not in a vault or metal-enclosed switchgear, the requirements for the overcurrent protection and disconnecting means may be fulfilled by the following:

(1) Air load-interrupter switches, or other approved switches, capable of interrupting the rated circuit load may be used with suitable fuses on a pole or elevated structure outside the building provided the switch may be operated by persons using the building.

(2) On circuits of any voltage, an automatic trip circuit-breaker of suitable ampacity and interrupting capacity with an overcurrent unit in each ungrounded conductor may be used. The circuit-breaker shall be located outside the building as near as practicable to where the service conductors enter the building. The location may be on a pole, roof, foundation, or other structure.

(c) Fuses. Fuses used as permitted in Sections 230-106(a) and (b) shall have an interrupting rating at least equal to the maximum short-circuit current possible in the circuit.

(d) Circuit Breakers. Circuit breakers shall be free to open in case the circuit is closed on an overload. This can be accomplished by means such as trip-free breakers or by multiple breakers having an operating handle per pole. A service circuit breaker shall indicate clearly whether it is open or closed, and shall be capable of interrupting the maximum short-circuit current to which it may be subjected.

(e) Enclosed Overcurrent Devices. The restriction to 80 per cent of rating for an enclosed overcurrent device on continuous loads shall not apply to overcurrent devices installed in services operating at over 600 volts.

230-107. Lightning Arresters. Lightning arresters installed in accordance with the requirements of Article 280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, when called for by the authority enforcing this Code.

ARTICLE 240 — OVERCURRENT PROTECTION

A. Installation

240-1. Scope. This Article provides the general requirements for the application of overcurrent protective devices.

240-2. Purpose of Overcurrent Protection. Overcurrent protection for conductors and equipment is provided for the purpose of opening the electric circuit if the current reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation.

240-3. Protection of Equipment. Equipment shall be protected against overcurrent as specified in the references in the following table:

Equipment	Article No.
Appliances	422
Capacitors	460
Cranes and Hoists	610
Elevators, Dumbwaiters and Escalators	620
Emergency Systems	700
Generators	445
Inductive and Dielectric Heat Generating Equipment	665
Machine Tools	670
Motion Picture Studios and Similar Locations	530
Motors	430
Organs	650
Over 600 Volts	710
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits	725
Services	230
Signs and Outline Lighting	600
Sound Equipment	640
Switchboards and Panelboards	384
Theaters and Assembly Halls	520
Transformers	450
Welders	630
X-ray Equipment	660

240-4. Time-Delay Overcurrent Devices. Circuit breakers and plug fuses installed in residential occupancies on circuits of 20 amperes or less shall be of the time-delay type.

240-5. Overcurrent Protection of Conductors. Conductors shall be protected in accordance with their ampacities, as given in Tables 310-12 through 310-15, except as follows:

Exception No. 1. Rating of Nonadjustable Overcurrent Protection of 800 Amperes or Less. When the standard ampere ratings of fuses and nonadjustable circuit breakers do not correspond with the allowable ampacities of conductors, the next higher standard rating may be used.

Exception No. 2. Adjustable-Trip Circuit Breakers. Adjustable-trip circuit breakers of the thermal trip, magnetic time-delay trip or instantaneous-trip types shall be set to operate at not more than 125 per cent of the allowable ampacity of the conductor.

The effect of the temperature on the operation of thermally controlled circuit breakers should be taken into consideration in the application of such circuit breakers when they are subjected to extremely low or extremely high temperatures.

Exception No. 3. Fixture Wires and Cords. Fixture wire or flexible cord, sizes No. 16 or No. 18, and tinsel cord shall be considered as protected by 20-ampere overcurrent devices except as provided in Section 620-61. Fixture wires of the sizes permitted for taps in Section 210-19(c-2) shall be considered as protected by the overcurrent protection of the 30-ampere and 50-ampere branch circuits of Article 210. Flexible cord approved for use with specific appliances shall be con-

sidered as protected by the overcurrent device of the branch circuit of Article 210 when conforming to the following:

20 ampere circuits, No. 18 cord and larger.

30 ampere circuits, cord of 10 amperes capacity and over.

50 ampere circuits, cord of 20 amperes capacity and over.

Exception No. 4. Motor Circuits. The conductors supplying motors and motor-operated appliances shall be considered as protected by the overcurrent protective devices specified in Sections 430-32, 430-34, 430-52, 430-53 and 430-62.

Exception No. 5. Remote Control. Except as provided in Article 725, the conductors of the control circuits of remote-control switches shall be considered as protected from overcurrent by overcurrent devices that are not of the so-called time-lag type and are rated or set at not more than 500 per cent of the ampacity of the remote-control conductors, as specified in Tables 310-12 through 310-15.

240-6. Fuses.

(a) If the allowable ampacity of a conductor does not correspond to the rating of a standard-size fuse, the next larger size or rating of fuse may be used only where the rating is 800 amperes or less.

(b) Standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 and 6000. Fuses with ampere rating other than the standard rating listed may be used when they are of an ampere rating smaller than those included in the standard list.

(c) Plug fuses and fuseholders shall not be used in circuits exceeding 125 volts between conductors except in circuits supplied from a system having a grounded neutral and no conductor in such circuits operating at more than 150 volts to ground.

(d) Cartridge fuses and fuseholders rated at 300 volts shall not be used in circuits exceeding 300 volts between conductors except in circuits supplied from a system having a grounded neutral and no conductor in such circuits operating at more than 300 volts to ground.

(e) The screw-shell of plug-type fuseholders shall be connected to the load side of the circuit.

240-7. Nonadjustable-Trip Circuit Breakers.

(a) Nonadjustable-trip circuit breakers, except as otherwise permitted in Note 10 to Tables 310-12 through 310-15 shall be rated in accordance with the ampacity of the conductor. When the allowable ampacity of a conductor does not correspond to the rating of a standard-size circuit breaker, the next larger size or rating of circuit breaker may be used only where the rating is 800 amperes or less.

(b) Standard ampere ratings for circuit breakers are 15, 20, 30, 40, 50, 60, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500, 600, 700, 800, 1000, 1200 and 1600.

240-8. Thermal Devices. Thermal cutouts, thermal relays and other devices not designed to open short-circuits, shall not be used for protection of conductors against overcurrent due to short-circuits or grounds but may be used to protect motor branch circuit conductors from overload if protected in accordance with Section 430-40.

240-9. Feeders at Supply Stations. Each conductor of a constant-potential circuit entering or leaving a supply station, except grounded neutral conductors, shall be protected from excessive current by a circuit breaker, or by an equivalent device of approved design. Such protective devices shall be located as near as practicable to the point where the conductors enter or leave the building. For the outgoing circuits not connected with other sources of power, the protective devices may be placed on the supply side of transformers or similar devices.

240-11. Ungrounded Conductors.

(a) An overcurrent device (fuse or overcurrent trip unit of a circuit breaker) shall be placed in each ungrounded conductor. The number and position of the overcurrent units such as trip coils or relays shall be as given in Table 240-28.

(b) Circuit breakers shall open all ungrounded conductors of the circuit, except as follows:

Exception: Individual single-pole circuit breakers may be used for the protection of each conductor of ungrounded 2-wire circuits, each ungrounded conductor of 3-wire direct-current or single-phase circuits, or for each ungrounded conductor of lighting or appliance branch circuits connected to 4-wire three-phase systems, or 5-wire 2-phase systems, provided such lighting or appliance circuits are supplied from a system having a grounded neutral and no conductor in such circuits operates at a voltage greater than permitted in Section 210-6.

240-12. Grounded Conductor. No overcurrent device shall be placed in any permanently grounded conductor, except as follows:

Exception No. 1. Where the overcurrent device simultaneously opens all conductors of the circuit.

Exception No. 2. For motor-running protection as provided in Sections 430-36 and 430-37.

240-13. Change in Size of Grounded Conductor. Where a change occurs in the size of the ungrounded conductor, a similar change may be made in the size of the grounded conductor.

240-14. Fuses in Multiple. For the protection of conductors having allowable ampacities exceeding the rating of the largest approved cartridge type fuse in Section 240-23(a-1), such cartridge fuses arranged in multiple may be used, provided as few fuses as possible are used and the fuses are of the same type, characteristics, and rating, and provided the fuseholder terminals are mounted on a single continuous pair of bus-bars, or have an equivalent arrangement that will eliminate any potential difference between the terminals of the fuses.

B. Location

240-15. Location in Circuit. Overcurrent devices shall be located at the point where the conductor to be protected receives its supply, except as follows:

Exception No. 1. Service Conductors. An overcurrent protective device for service conductors may be located as specified in Section 230-91.

Exception No. 2. Smaller Conductor Protected. Where the overcurrent device protecting the larger conductors also protects the smaller conductors in accordance with Tables 310-12 through 310-15.

Exception No. 3. Branch Circuits. Taps to individual outlets and circuit conductors supplying a single household electric range shall be considered as protected by the branch circuit overcurrent devices when in accordance with the requirements of Sections 210-19 and 210-20.

Exception No. 4. Feeder Taps. A conductor tapped from a feeder shall be considered as properly protected from overcurrent when installed in accordance with Sections 210-25, 364-8 and 430-58.

Exception No. 5. Feeder Taps Not Over 10 Feet Long. Where (1) the smaller conductor has an ampacity of not less than the sum of the allowable ampacities for the conductors of the one or more circuits or loads supplied, and (2) the tap is not over 10 feet long and does not extend beyond the switchboard, panelboard, or control devices which it supplies, and (3) except at the point of connection to the feeder, the tap is enclosed in conduit, electrical metallic tubing, or in metal gutters when not a part of the switchboard or panelboard.

Exception No. 6. Feeder Taps Not Over 25 Feet Long. Where the smaller conductor has an ampacity at least one-third that of the conductor from which it is supplied, and provided the tap is suitably protected from physical damage, is not over 25 feet long, and terminates in a single circuit breaker or set of fuses which will limit the load on the tap to that allowed by Tables 310-12 through 310-15. Beyond this point the conductors may supply any number of circuit breakers or sets of fuses.

240-16. Location in Premises. Overcurrent devices shall be located where they will be:

(a) Readily accessible, except as provided in Sections 230-91 and 230-92 for service equipment and Section 364-11 for busways.

(b) Not exposed to physical damage.

(c) Not in the vicinity of easily ignitible material.

C. Enclosures

240-17. Enclosures for Overcurrent Devices.

(a) General. Overcurrent devices shall be enclosed in cutout boxes or cabinets, unless a part of a specially approved assembly which affords equivalent protection, or unless mounted on switchboards, panelboards or controllers located in rooms or enclosures free from easily ignitible material and dampness. The operating handle of a circuit breaker may be accessible without opening a door or cover.

(b) Damp or Wet Locations. Enclosures for overcurrent devices in damp or wet locations shall be of a type approved for such locations and shall be mounted so there is at least one-fourth inch air space between the enclosure and the wall or other supporting surface.

(c) Vertical Position. Enclosures for overcurrent devices shall be mounted in a vertical position unless in individual instances this is shown to be impracticable.

(d) Rosettes. Fuses shall not be mounted in rosettes.

D. Disconnecting and Guarding

240-18. Disconnection of Fuses and Thermal Cutouts Before Handling. Disconnecting means shall be provided on the supply side of all fuses or thermal cutouts in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage, where accessible to other than qualified persons, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electrical energy, except as provided in Section 230-73 and except that a single disconnecting means may be used to control a group of circuits each protected by fuses or thermal cutouts under the conditions described in Section 430-112.

240-19. Arcing or Suddenly Moving Parts. Arcing or suddenly moving parts shall comply with the following:

(a) Location. Fuses and circuit breakers shall be so located or shielded that persons will not be burned or otherwise injured by their operation.

(b) Suddenly Moving Parts. Handles or levers of circuit breakers, and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

E. Plug Fuses and Fuseholders

240-20. Plug Fuses of the Edison-Base Type. Plug fuses of the Edison-base type shall conform to the following:

(a) Classification. Plug fuses of this type shall be classified at not over 125 volts, 0 to 30 amperes.

(b) Live Parts. Fuses and fuseholders when installed and assembled together shall have no live parts exposed.

(c) Marking. Plug fuses of 15 amperes rating or less shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or by some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

Plug fuses of the Edison-base type are recognized in this Code only as a replacement item in existing installations.

240-21. Fuseholders for Plug Fuses. Fuseholders for plug fuses of 30 amperes or less shall not be installed unless they comply with Section 240-22 or are made to comply with Section 240-22 by the insertion of an adapter.

240-22. Plug Fuses and Fuseholders of Type S. Where Type S plug fuses are to be used as the overcurrent device required by this Code, the fuses and fuseholders shall conform to the following requirements:

(a) Classification. Plug fuses and fuseholders of Type S shall be classified at not over 125 volts; 0 to 15 amperes, 16 to 20 amperes, and 21 to 30 amperes.

(b) Use of Fuses in a Fuseholder of a Different Classification. Fuses of the 16 to 20 ampere and the 21 to 30 ampere classification shall not be usable with fuseholders or adapters of a lower ampere classification.

(c) Fuseholders and Adapters. Fuses, fuseholders, and adapters shall be so designed that a fuse other than a Type S fuse cannot be used in a fuseholder or adapter designed for Type S fuses.

(d) Tamperability. Fuses, fuseholders and adapters shall be so designed as to be subject to tampering or bridging only with difficulty.

(e) Adapters to be Nonremovable. Fuse adapters shall be so designed that when once inserted in a fuseholder they cannot be removed.

(f) Interchangeability. Fuses, fuseholders and adapters of various manufacturers shall be interchangeable with each other, and the plugs with adapters shall be suitable for use in the Edison-base type fuseholder.

(g) Plug Type. Fuses and fuseholders shall be of the plug type.

(h) Ampere Rating. Each fuse, fuseholder and adapter shall be marked with its ampere rating.

(i) Marking. Fuses of the 0 to 15 ampere rating shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

F. Cartridge Fuses and Fuseholders

240-23. Cartridge Fuses and Fuseholders. Cartridge fuses and fuseholders shall conform to the following:

(a) Classification.

(1) 0-600 ampere cartridge fuses and fuseholders shall be classified as regards current and voltage as follows:

Not over 250 volts Amperes	**Not over 300 volts Amperes**	**Not over 600 volts Amperes**
0- 30	0-15	0- 30
31- 60	16-20	31- 60
61-100	21-30	61-100
101-200	31-60	101-200
201-400	-	201-400
401-600	-	401-600

(2) 601-6000 ampere cartridge fuses and fuseholders shall be classified at 600 volts as follows:

601- 800	1601-2000	3001-4000
801-1200	2001-2500	4001-5000
1201-1600	2501-3000	5001-6000

There are no 250 volt ratings over 600 amperes, but 600 volt fuses may be used for lower voltages.

(b) Noninterchangeable—0-6000 Ampere Cartridge Fuseholders. Fuseholders shall be so designed that it will be difficult to put a fuse of any given class into a fuseholder which is designed for a current lower, or voltage higher, than that of the class to which it belongs. Fuseholders for current limiting fuses shall not permit insertion of fuses which are not current limiting.

(c) Marking. Fuses shall be plainly marked with the ampere rating, voltage rating, interrupting rating when greater than 10,000 amperes, current limitation where it applies, and the name or trademark of the maker. The marking shall be either by direct printing on the fuse barrel or by means of an attached label.

G. Link Fuses and Fuseholders

240-24. Link Fuses and Fuseholders. Link fuses and fuseholders shall be used only by special permission and shall conform to the following:

(a) Mounting. Link fuses shall be mounted on approved fuseholders.

(b) Dimensions. Link fuses and fuseholders shall have the following dimensions in inches:

Amperes Capacity	Minimum Separation of Nearest Metal Parts of Opposite Polarity	Minimum Break Distance
Not over 125 volts		
601-1500	1½	1½
Not over 250 volts		
601-1500	2¾	2

For 3-wire systems, link fuses, and fuseholders shall have the break distance required for circuits of the potential of the outside wires, except that in 125-250-volt systems with grounded neutral the fuses and fuseholders in 2-wire, 125-volt branch circuits may have the spacing specified for not over 125 volts.

(c) Spacing. A space shall be maintained between the fuse terminals of link fuses of the same polarity of at least ½ inch for voltages up to 125, and of at least ¾ inch for voltages from 126 to 250. This is the minimum distance allowable and greater separation shall be provided where practicable.

(d) Material. Contact surfaces or tops of link fuses shall be of copper or aluminum having good electrical connections with the fusible part of the strip.

(e) Minimum Rating. Link fuses and fuseholders shall be used only in sizes rated at more than 600 amperes, and only by special permission.

(f) Marking. Link fuses shall be stamped with 80 per cent of the maximum current which they can carry indefinitely.

H. Circuit Breakers

240-25. Circuit Breakers. Circuit breakers shall conform to the following:

(a) Method of Operation. In general, circuit breakers shall be capable of being closed and opened by hand without employing any other source of power, although normal operation may be by other power such as electrical, pneumatic, and the like. Large circuit breakers which are to be closed and opened by electrical, pneumatic, or other power shall be capable of being closed by hand for maintenance purposes and shall also be capable of being tripped by hand under load without the use of power.

(b) Type of Operation. Circuit breakers of the 0 to 30 ampere class should be of the time-delay type.

(c) Injury to Operator. Circuit breakers shall be arranged and mounted so that their operation is not likely to injure the operator.

(d) Indication. Circuit breakers shall indicate whether they are in the open or closed position.

(e) Nontamperable. An air circuit breaker, used for the branch circuits described in Article 210, shall be of such design that any alteration of its trip point (calibration), or in the time required for its operation, will be difficult.

(f) Marking. Circuit breakers shall be marked with their rating in such a manner that the marking will be durable and visible after installation except that it may be necessary to remove a trim or cover. The ampere rating of circuit breakers rated 100 amperes or less and 600 volts or less shall be molded, stamped, etched, or similarly marked into the handle or the escutcheon area of the circuit breaker. Each circuit breaker intended to interrupt fault currents greater than 10,000 amperes shall have its interrupting rating shown on the label or on the product.

240-27. Current Limiting Overcurrent Protective Device. A current limiting overcurrent protective device is a device which, when interrupting a specified circuit, will consistently limit the short-circuit current in that circuit to a specified magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Table 240-28. Number of Overcurrent Units, Such as Trip Coils or Relays, for Protection of Circuits

(See Diagrams 1 to 19 following this Table)

(See Section 240-11 for the overcurrent protection of conductors in general, Section 230-90 for services, and Section 430-37 for motors).

SYSTEMS	*Number and Location of Overcurrent Units.
2-Wire, Single-phase A.C. or D.C. Ungrounded.	Two (one in each conductor. Diagram 1).
2-Wire, Single-phase A.C. or D.C., One Wire Grounded.	One (in ungrounded conductor. Diagram 2).
2-Wire, Single-phase A.C. or D.C., Mid-point Grounded.	Two (one in each conductor. Diagram 3).

SYSTEMS	*Number and Location of Overcurrent Units.
2-Wire, Single-phase A.C. Derived from 3-Phase, with Ungrounded Neutral.	Two (one in each conductor. Diagram 4).
2-Wire, Single-phase Derived from 3-Phase, Grounded Neutral System by Using outside Wires of 3-Phase Circuit.	Two (one in each conductor. Diagram 5).
3-Wire, Single-phase A.C. or D.C. Ungrounded Neutral.	Three (one in each conductor. Diagram 6).
3-Wire, Single-phase A.C. or D.C. Grounded Neutral.	Two (one in each conductor except neutral conductor. Diagram 7).
3-Wire, 2-Phase, A.C. Common Wire Ungrounded.	Three (one in each conductor. Diagram 8).
3-Wire, 2-Phase, A.C., Common Wire Grounded.	Two (one in each conductor except common conductor. Diagram 9).
4-Wire, 2-Phase Ungrounded, Phases Separate.	Four (one in each conductor. Diagram 10).
4-Wire, 2-Phase, Grounded Neutral, or 5-Wire, 2-Phase, Grounded Neutral.	Four (one in each conductor except neutral conductor. Diagrams 11 and 12).
3-Wire, 3-Phase, Ungrounded.	Three (one in each conductor. Diagram 13**).
3-Wire, 3-Phase, 1 Wire Grounded.	Two (one in each ungrounded conductor. Diagram 14).
3-Wire, 3-Phase, Grounded Neutral.	Three (one in each conductor. Diagram 15**).
3-Wire, 3-Phase, Mid-point of one phase grounded.	Three (one in each conductor. Diagram 17**).
4-Wire, 3-Phase, Grounded Neutral.	Three (one in each ungrounded conductor. Diagram 18**).
4-Wire, 3-Phase, Ungrounded Neutral.	Four (one in each conductor. Diagram 19).

Notes to Table 240-28

*1. An overcurrent unit may consist of a series overcurrent tripping device or the combination of a current transformer and a secondary overcurrent tripping device. Either two or three secondary overcurrent tripping devices may be used with three current transformers on a 3-phase system similar to those shown in Diagrams 15 and 18.

**2. When three current transformers are used instead of three series overcurrent tripping devices shown in Diagrams 13, 15, 17 and 18, the secondary tripping devices may consist of three secondary overcurrent tripping devices or two secondary overcurrent tripping devices with a residual current tripping device of a lower range. See Diagram 16.

3. Where standard devices are not available with three or four overcurrent units as required in the Table, it is permissible to substitute two overcurrent units and one fuse where three overcurrent units are called for, two overcurrent units and two fuses where four overcurrent units are called for. The fuse or fuses are to be placed in the conductors not containing an overcurrent unit. This practice, however, of substituting fuses for overcurrent units is to be discouraged for obvious reasons.

Diagrams 240-29

Diagrams 1 to 19 showing Number of Overcurrent Units such as Trip Coils or Relays for the Protection of Circuits as required by Table 240-28.

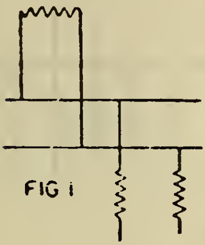

FIG 1

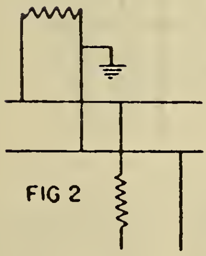

FIG 2

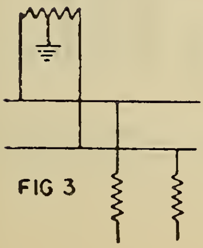

FIG 3

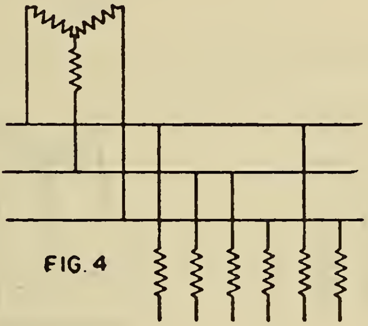

FIG. 4

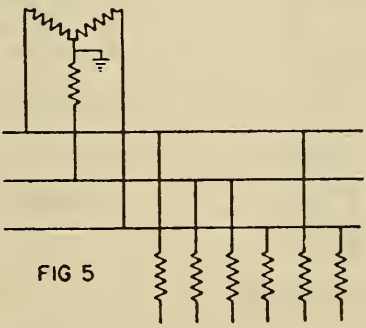

FIG 5

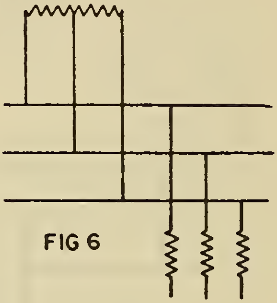

FIG 6

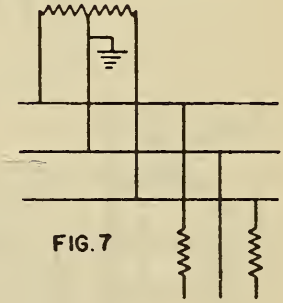

FIG.7

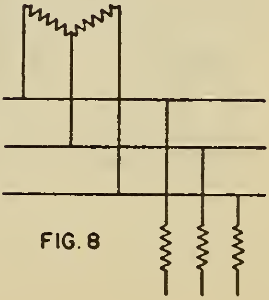

FIG. 8

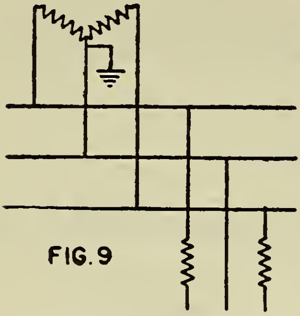

FIG. 9

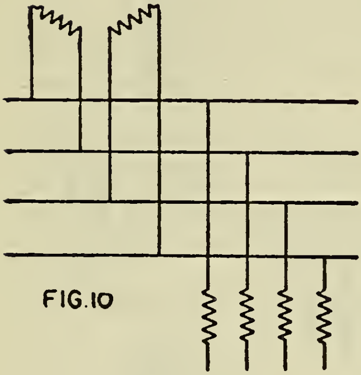

FIG. 10

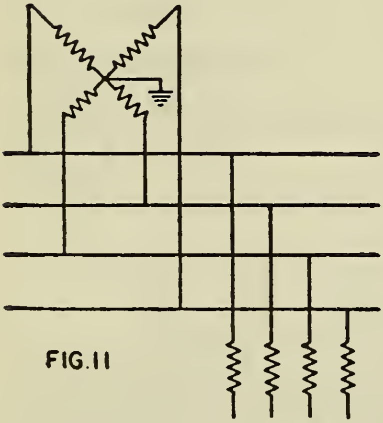

FIG. 11

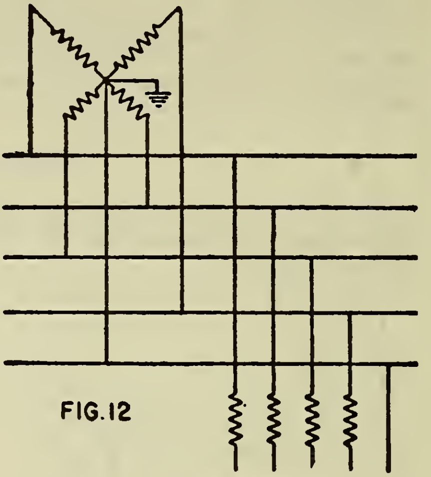

FIG. 12

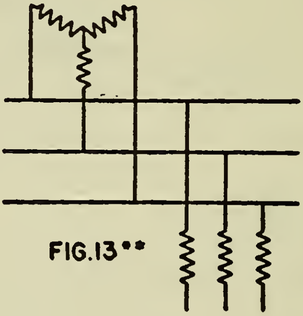

FIG. 13**

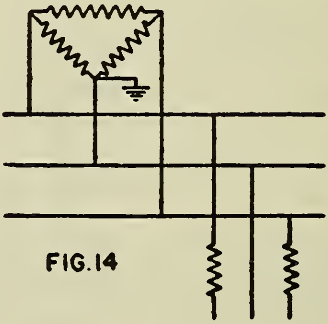

FIG. 14

**See Note 2 of Table 240-28

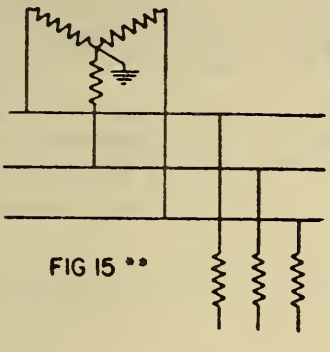

FIG 15 **

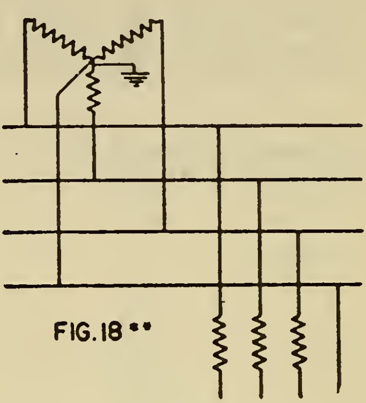

FIG. 18 **

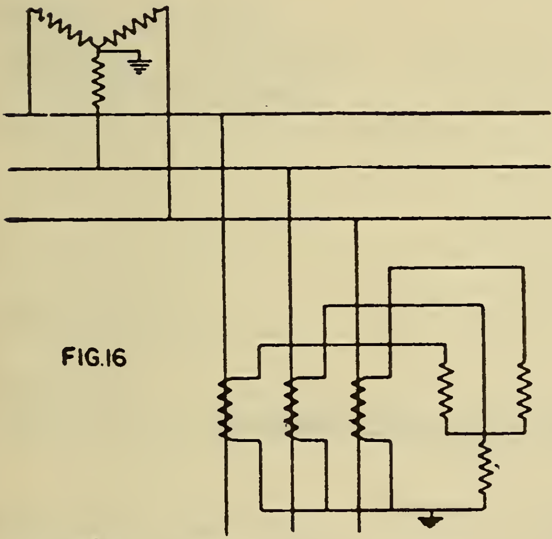

FIG. 16

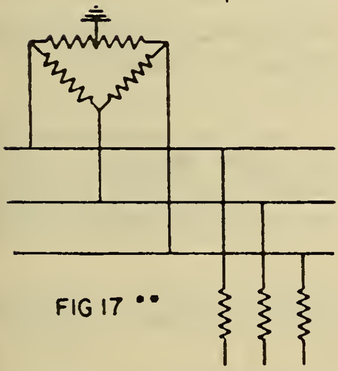

FIG 17 **

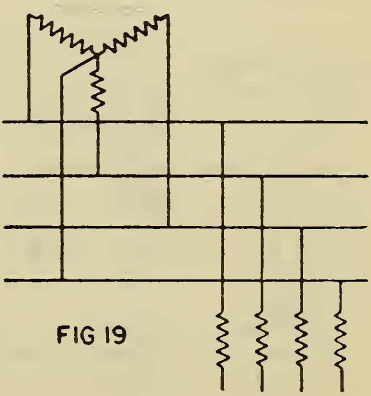

FIG 19

**See Note 2 of Table 240-28.

240-30. Supplementary Overcurrent Protection. Where supplementary overcurrent protection is utilized in connection with appliances or other utilization equipment to provide individual protection for specific components or internal circuits within the equipment itself, this does not abrogate any of the requirements applicable to branch circuits and is not to be used as a substitute for branch-circuit protection.

It is not the intent of the above requirement that supplementary overcurrent protective devices be subject to the accessibility requirements as given elsewhere in this code for branch circuit overcurrent protective devices.

ARTICLE 250—GROUNDING

A. General

250-1. Scope. This Article treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions. See Section 110-17.

(a) Systems and Circuits. Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

(b) Exposed Conductor Enclosures. Exposed conductive materials enclosing electric conductors are grounded for the purpose of preventing a potential above ground on the enclosures.

(c) Exposed Equipment Enclosures. Exposed conductive materials enclosing electric equipment, or forming a part of such equipment, are grounded for the purpose of preventing a potential above ground on the equipment.

250-2. Other Articles. In other Articles, applying to particular cases of installation of conductors and equipment, there are requirements that are in addition to those of this Article or are modifications of them:

	Article	Section
Appliances	422	422-12
Branch Circuits	210	210-5 210-6
Communications Circuits	800	
Conductors	200	
	310	310-2
Cranes and Hoists	610	
Elevators, Dumbwaiters, Escalators, and Moving Walks	620	
Fixtures & Lighting Equipment	410	410-91 410-92 410-93 410-94 410-95 410-96
Flexible Cords	400	400-13 400-14
Generators	445	445-8
Grounding Receptacles (Outlets)	210	210-7 210-21 210-22
Hazardous Locations	500-517	
Inductive and Dielectric Heat Generating Equipment	665	
Less Than 50 V	720	
Lighting Fixtures	410	
Metalworking Machine Tools	670	
Mobile Homes	550	
Motion Picture Studios	530	530-19 530-66
Motors and Controllers	430	
Organs	650	
Outlet, Switch and Junction Boxes, and Fittings	370	370-4 370-15
Radio and Television	810	

Receptacles & Attachment Plugs	410	410-55 410-56
Remote Control Circuits	725	725-21
Room Air Conditioners	422	422-61
Services	230	
Service Equipment	230	230-63
Signs and Outline Lighting	600	
Sound Recording Equipment	640	640-4
Swimming Pools	680	
Switchboards	384	384-11
Switches	380	380-1 380-12
Theaters & Assembly Halls	520	520-81
Transformers	450	450-8
Travel Trailers	551	
X-ray Equipment	660	

B. Circuit and System Grounding

250-3. Two-Wire Direct-Current Systems. Two-wire direct-current systems supplying interior wiring, and operating at not more than 300 volts between conductors, shall be grounded, unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.

> All two-wire direct-current systems operating at more than 300 volts between conductors shall be grounded when a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. All two-wire direct-current systems shall not be grounded when the voltage to ground of either conductor would exceed 300 volts after grounding.

250-4. Three-Wire Direct-Current Systems. The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded.

250-5. Alternating-Current Systems. Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, except those covered in Sections 250-6, 250-7 and 250-8, shall be grounded when they can be so grounded that the maximum voltage to ground does not exceed 150 volts. Where a service conductor is uninsulated in accordance with Section 230-4, the system shall be grounded.

> All alternating-current systems shall be grounded as provided in this article when the voltage to ground does not exceed 300 volts. Higher voltage systems may be grounded.
>
> Ungrounded systems supplying industrial equipment and operating at more than 150 volts and less than 600 volts shall be equipped with ground detectors.

250-6. Furnace Circuits. Electric furnace circuits need not be grounded.

250-7. Electric Crane Circuits. Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See Section 503-13.

250-8. Circuits of Less than 50 Volts. Circuits of less than 50 volts need not be grounded, except as follows:

(a) Where supplied by transformers from systems of more than 150 volts to ground, except as provided in Section 250-45(d).

(b) Where supplied by transformers from ungrounded systems.

(c) Where run overhead outside buildings.

C. Location of Grounding Connections

250-21. Current Over Grounding Conductors. The grounding of wiring systems, circuits, arresters, cable armor, conduit, or other metal raceways as a protective measure shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable. Where an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the authority enforcing this Code shall be taken to limit the current.

250-22. Grounding Connection for Direct-Current Systems. Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

250-23. Grounding Connections for Alternating-Current Systems.

(a) Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each individual service, except as provided for in Section 250-21. The connection shall be made on the supply side of the service disconnecting means. Each secondary distribution system which is grounded shall have at least one additional connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means, except as provided for in Section 250-24.

(b) Where the secondary system is grounded at any point, the grounded conductor shall be run to each individual service. This conductor shall be not smaller than the required grounding conductor specified in Table 250-94(a).

250-24. Two or More Buildings Supplied by a Single Service. Where more than one building is supplied by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building housing equipment required to be grounded or utilizing two or more branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

250-25. Conductor to be Grounded. For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

(a) Single-phase, 2-wire: the identified conductor;

(b) Single-phase, 3-wire: the identified neutral conductor;

(c) Multiphase systems having one wire common to all phases: the identified common conductor;

(d) Multiphase systems having one phase grounded: the identified conductor;

(e) Multiphase systems in which one phase is used as in (b): the identified neutral conductor. One phase only can be grounded.

See Article 200.

The identified conductor is commonly known as "the white wire."

250-26. Isolated Systems. For an interior wiring system or circuit which is required to be grounded and which is not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard, on the supply side of the first switch controlling the system. See fine print note following Section 200-3.

D. Enclosure Grounding

250-32. Service Conductor Enclosures. Service raceways, service cable sheaths or armoring, when of metal, shall be grounded.

250-33. Other Conductor Enclosures. Metal enclosures for conductors shall be grounded, except they need not be grounded in runs of less than 25 feet which are free from probable contact with ground, grounded metal, metal lath or conductive thermal insulation and which, where within reach from grounded surfaces, are guarded against contact by persons.

250-34. Spacing from Lightning Rods. Metal enclosures of conductors shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together.

E. Equipment Grounding

250-42. Fixed Equipment—General. Under any of the following conditions, exposed, noncurrent-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

(a) Where equipment is supplied by means of metal-clad wiring;

(b) Where equipment is located in a wet location and is not isolated;

(c) Where equipment is located within reach of a person who can make contact with any grounded surface or object;

(d) Where equipment is located within reach of a person standing on the ground;

(e) Where equipment is in a hazardous location; see Articles 500-517 inclusive;

(f) Where equipment is in electrical contact with metal or metal lath;

(g) Where equipment operates with any terminal at more than 150 volts to ground, except as follows:

(1) Enclosures for switches or circuit breakers where accessible to qualified persons only;

(2) Metal frames of electrically heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground;

(3) Transformers mounted on wooden poles at a height of more than 8 feet from the ground.

250-43. Fixed Equipment—Specific. Exposed, noncurrent-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:

(a) Frames of motors as specified in Section 430-142;

(b) Controller cases for motors, except lined covers of snap switches;

(c) Electric equipment of elevators and cranes;

(d) Electric equipment in garages, theatres and motion picture studios, except pendant lampholders on circuits of not more than 150 volts to ground;

(e) Motion-picture projection equipment;

(f) Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;

(g) Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;

(h) Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded where effectively insulated;

(i) Equipment supplied by Class 1 and Class 2 remote control and signaling circuits where Part B of this article requires those circuits to be grounded.

250-44. Nonelectrical Equipment. The following metal parts shall be grounded:

(a) Frames and tracks of electrically operated cranes;

(b) The metal frame of a nonelectrically driven elevator car to which electric conductors are attached;

(c) Hand-operated metal shifting ropes or cables of electric elevators;

(d) Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

Where extensive metal in or on buildings may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety.

250-45. Portable Equipment. Under any of the following conditions, exposed noncurrent-carrying metal parts of portable equipment, which are liable to become energized, shall be grounded:

(a) In hazardous locations (see Articles 500 to 517);

(b) When operated at more than 150 volts to ground, except:

(1) Motors, where guarded;

(2) Metal frames of electrically heated appliances exempted by Section 422-12.

(c) In residential occupancies, (1) clothes-washing, clothes-drying, and dish-washing machines, sump pumps, and (2) portable, hand held, motor operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

Exception: Such tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. Where such an approved system is employed the equipment shall be distinctively marked.

Portable tools or appliances not provided with special insulating or grounding protection are not intended to be used in damp, wet or conductive locations.

(d) In other than residential occupancies, (1) portable appliances used in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, and (2) portable tools which are likely to be used in wet and conductive locations shall be grounded except that they need not be grounded where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

The frames of all portable motors which operate at more than 50 volts and less than 150 volts to ground shall be grounded, where this can be readily accomplished.

250-46. Spacing from Lightning Rods. Metal frames and enclosures of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together. See Sections 250-34 and 250-86.

F. Methods of Grounding

250-51. Effective Grounding. The path to ground from circuits, equipment, and conductor enclosures shall (1) be permanent and continuous and (2) shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

250-52. Location of System Ground Connection. The grounding conductor may be connected to the grounded conductor of the wiring system at any convenient point on the premises on the supply side of the service disconnecting means.

High capacity services shall have the grounding conductor connected to the grounded circuit conductor within the service entrance equipment enclosure.

250-53. Common Use of Grounding Conductor. The grounding conductor of a wiring system shall also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

Exception: The grounding connection as covered in the exception in Section 210-7 may be made to a grounded cold water pipe near the equipment.

250-54. Common Grounding Electrode. Where the alternating-current system is connected to a grounding electrode in or at a building as specified in Sections 250-23 and 250-24, the same electrode shall be used to ground conductor enclosures and equipment in or on that building.

250-55. Underground Service Cable. Where served from a continuous underground metal-sheathed cable system, the sheath or armor of underground service cable metallically connected to the underground system, or underground service conduit containing a metal-sheathed cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

250-56. Short Sections of Raceway. Isolated sections of metal raceway or cable armor, where required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with Section 250-57.

250-57. Fixed Equipment.

(a) Metal boxes, cabinets and fittings, or noncurrent-carrying metal parts of other fixed equipment, where metallically connected to grounded cable armor or metal raceway, are considered to be grounded by such connection.

(b) Where not so connected they may be grounded in one of the following ways:

(1) By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but where it is provided with an individual covering, the covering shall be finished a continuous green color or a continuous green color with a yellow stripe.

(2) By a separate grounding conductor installed the same as a grounding conductor for conduit and the like;

(3) By a grounding conductor in the supply cord, when cord connected as permitted in Section 400-3;

(4) By special permission, other means for grounding fixed equipment may be used.

250-58. Equipment on Structural Metal.

(a) Electric equipment secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded.

(b) Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded where the machine is grounded in accordance with this Code.

250-59. Portable Equipment. Noncurrent-carrying metal parts of portable equipment may be grounded in any one of the following ways:

(a) By means of the metal enclosure of the conductors feeding such equipment, provided an approved grounding-type attachment plug is used, one fixed contacting member being for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure of the conductors is attached to the attachment plug and to the equipment by connectors approved for the purpose;

Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of hand-held tools or hand-held appliances may be of the movable self-restoring type.

Attachment plug caps are not intended to be used as terminations for metal-clad cable or flexible metal conduit.

(b) By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord that is properly terminated in an approved grounding-type attachment plug having a fixed grounding contacting member. The grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished a continuous green color or a continuous green color with a yellow stripe.

Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of hand-held tools or hand-held appliances may be of the movable self-restoring type.

(c) Separate flexible wire or strap, insulated or bare, when used for portable equipment shall be protected against physical damage.

250-60. Frames of Electric Ranges and Electric Clothes Dryers. Frames of electric ranges and electric clothes dryers shall be grounded by any of the means provided for in Sections 250-57 and 250-59 or where served by 120-240 volt, three-wire branch circuits, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. The frames of wall-mounted ovens and counter-mounted cooking units shall be grounded and may be grounded in the same manner as electric ranges.

250-61. Grounding Equipment to Circuit Conductor. The grounded service conductor on the supply side of the service disconnecting means may be used for grounding meter housing and service equipment and metallic enclosures and guards. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in Section 250-57(b-4), and in Section 250-60.

G. Bonding

250-71. Bonding at Service Equipment. The electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in Section 250-72.

(a) The service raceways or service cable armor or sheath, except as provided in Section 230-63(b) and Section 250-55;

(b) All service equipment enclosures containing service entrance conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor;

(c) Any conduit or armor which forms part of the grounding conductor to the service raceway.

250-72. Continuity at Service Equipment. Electrical continuity at service equipment shall be assured by one of the following means:

(a) Bonding equipment to the grounded service conductor in a manner provided in Section 250-113.

(b) Threaded couplings and threaded bosses on enclosures with joints shall be made up wrenchtight where rigid conduit is involved.

(c) Threadless couplings made up tight for rigid conduit and electrical metallic tubing.

(d) Bonding jumpers meeting the other requirements of this article. Bonding jumpers shall be used around concentric or eccentric knockouts which are punched or otherwise formed so as to impair the electrical connection to ground.

(e) Other devices (not locknuts and bushings) approved for the purpose.

250-73. Metal Armor or Tape of Service Cable. With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

250-74. Bonding at Grounding-Type Receptacles. Grounding continuity between a grounded outlet box and the grounding circuit of the receptacle shall be established by means of a bonding jumper between the outlet box and the receptacle grounding terminal.

Exception No. 1: When the box is surface-mounted, direct metal-to-metal contact between the device yoke and the box may be used to establish the grounding circuit.

Exception No. 2: Contact devices or yokes designed and approved for the purpose may be used in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes installed in walls.

250-75. Continuity at Other Enclosures. The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any nonconducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

250-76. Voltages Exceeding 250 Volts. The electrical continuity of metal raceway or metal sheathed cable which contains any conductor other than service entrance conductors of more than 250 volts to ground shall be assured by one of the methods specified in Section 250-72(b-e), or by one of the following methods:

(a) Threadless fittings, made up tight, with conduit or metal-clad cable;

(b) Two locknuts, one inside and one outside of boxes and cabinets.

250-77. Loosely Jointed Metal Raceways. Expansion joints and telescoping sections of raceways shall be made electrically continuous by bonding jumpers or other approved means. Metal trough raceways used in connection with sound recording and reproducing, made up in sections, shall contain a grounding conductor to which each section shall be bonded.

250-78. Hazardous Locations. In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in Section 250-72(b-e).

250-79. Bonding Jumpers. Bonding jumpers shall conform to the following:

(a) Material and Size. Bonding jumpers shall be of copper or other corrosion-resistant material and shall be of sufficient size to have ampacity not less than is required in Table 250-94(a).

(b) Attachment. Bonding jumpers shall be attached to cabinets and the like in a manner provided in Section 250-113; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in Section 250-114.

H. Grounding Electrodes

250-81. Water Pipe. A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. Where the buried portion of the metallic piping system is less than ten feet (including well casings bonded to the piping system) or there is some likelihood of the piping system being disconnected or isolated through the use of nonmetallic piping or insulated couplings, the piping system shall be supplemented by one or more of the grounding electrodes recognized in Sections 250-82 and 250-83. The interior metallic cold water piping system shall always be bonded to the one or more grounding electrodes.

Expanding use of nonmetallic piping for water systems and insulating couplings on metallic water systems makes it more important that water piping within a building be adequately grounded without depending on connections to an outside piping system. The interior piping system should be electrically continuous. Bonding to sewer, hot water piping and metallic air ducts within the premises will provide additional safety.

250-82. Other Available Electrodes. Where a water system as described in Section 250-81 is not available, the grounding connection may be made to any of the following:

(a) The metal frame of the building, where effectively grounded.

(b) Underground gas service piping shall not be used as a grounding electrode.

250-83. Made Electrodes. Where electrodes described in Sections 250-81 and 250-82 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried plate or other device approved for the purpose and conforming to the following requirements:

(a) Plate Electrodes. Each plate electrode shall present not less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel plates shall be at least ¼ inch in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch in thickness.

(b) Pipe Electrodes. Electrodes of pipe or conduit shall be not smaller than of the ¾-inch trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(c) Rod Electrodes. Electrodes of rods of steel or iron shall be at least ⅝ inch in diameter. Approved rods of nonferrous materials or their approved equivalent used for electrodes shall be not less than ½ inch in diameter.

(d) Installation. Electrodes should, as far as practicable, be imbedded below permanent moisture level. Except where rock bottom is encountered, pipes or rods shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Pipes or rods when less than standard commercial length shall preferably be of one piece. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel or other poorly conducting materials. Where rock bottom is encountered at a depth of less than 4 feet, electrodes shall be buried in a horizontal trench, and where pipes or rods are used as the electrode they shall comply with Section 250-83(b and c) and shall not be less than 8 feet in length. Each electrode shall be separated at least 6 feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose.

250-84. Resistance. Made electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, two or more electrodes connected in parallel shall be used.

Continuous metallic underground water piping systems in general have a resistance to ground of less than 3 ohms. Metal frames of buildings and local metallic underground piping systems, metal well casings, and the like, have, in general, a resistance substantially below 25 ohms. It is recommended that in locations where it is necesssary to use made electrodes for grounding interior wiring systems, additional grounds, such as connections to a system ground conductor be placed on the distribution circuit. It is also recommended that single electrode grounds when installed, and periodically afterwards, be tested for resistance.

250-85. Railway Tracks. Rails or other grounded conductors of electric railway circuits shall not be used (a) as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, where other effective grounds are available; and (b) in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself.

250-86. Use of Lightning Rods. Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this Article for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. See Section 800-31(b-5).

All separate electrodes shall be bonded together to limit potential differences between them and between their associated wiring systems.

J. Grounding Conductors

250-91. Material. The material for the grounding conductors shall be as follows:

(a) **For System or Common Grounding Conductor.** The grounding conductor of a wiring system shall be of copper or other corrosion-resistant material. The conductor may be solid or stranded, insulated or bare. Except in cases of bus-bars, the grounding conductor shall be without joint or splice throughout its length. Where the grounding conductor is not of copper, its electrical resistance per linear foot shall not exceed that of the allowable copper conductor for such a purpose.

(b) **For Conductor Enclosures and Equipment Only.** The grounding conductor for equipment and for conduit and other metal raceways or enclosures for conductors, shall be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus-bar or a rigid conduit, steel pipe, electrical metallic tubing or the armor of Type AC metal-clad cable, except that under conditions favorable to corrosion, a suitable corrosion-resistant material shall be used. Where conduit is used as a grounding conductor, all joints and fittings shall be made wrenchtight.

250-92. Installation. Grounding conductors shall be installed as follows:

(a) **System or Common Grounding Conductor.** A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe physical damage. A No. 6 grounding conductor, which is free from exposure to physical damage, may be run along the surface of the building construction without metal covering or protection, where it is rigidly stapled to the construction;

otherwise, it shall be in conduit or electrical metallic tubing.

Grounding conductors smaller than No. 6 shall be in conduit or electrical metallic tubing. Metallic enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened with an approved fitting. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirement of Article 346; where electrical metallic tubing is used, the installation shall comply with the requirements of Article 348. Aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum grounding conductors shall not be installed within 18 inches of the earth.

(b) Conductor Enclosures and Equipment Only. A grounding conductor for conductor enclosures and equipment only shall meet the requirements of Section 250-92(a), except that where smaller than No. 6, as permitted by Section 250-95.

Wires in a raceway where run through the hollow spaces of a wall or partition shall be installed so as not to be subject to physical damage.

250-93. Direct Current Systems. The ampacity of the grounding conductor for a direct-current supply system or generator shall be not less than that of the largest conductor supplied by the system, except that where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of Section 445-4(d), the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

250-94. Alternating Current Systems.

(a) Service and Common Grounding Conductor for Grounded Systems. Where the wiring system is grounded, the size of the grounding conductor for an alternating current system or for a common grounding conductor shall not be less than is given in Table 250-94.(a), except that where connected to made electrodes (as in Section 250-83.), that portion of the grounding conductor which is the sole connection between the grounding electrode and the grounded system conductor need not be larger than No. 6 copper wire or its equivalent in ampacity.

(b) Service Equipment Grounding Conductor for Ungrounded Systems. Where the wiring system is ungrounded, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall not be less than is given in Table 250-94.(b), except that where connected to made electrodes (as in Section 250-83) that portion of the grounding conductor which is the sole connection between the grounding electrode and the service equipment need not be larger than No. 6 copper wire or its equivalent in ampacity.

250-95. Interior Raceway and Equipment. The size of the grounding conductor for conduit, cable sheath or armor, and other metal raceways or enclosures for conductors, and for equipment, shall be not less than given in Table 250-95.

Table 250-94(a)
Service and Common Grounding Conductor for Grounded Systems

Size of Largest Service Conductor or Equivalent for Multiple Conductors		Size of Grounding Conductor AWG No.	
Copper	Aluminum	Copper	Aluminum*
2 or smaller	0 or smaller	8	6
1 or 0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250 MCM	4	2
Over 3/0 to 350 MCM	Over 250 MCM to 500 MCM	2	0
Over 350 MCM to 600 MCM	Over 500 MCM to 900 MCM	0	3/0
Over 600 MCM to 1100 MCM	Over 900 MCM to 1750 MCM	2/0	4/0
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM

*See installation restrictions in Section 250-92(a).

Table 250-94(b)
Service Equipment Grounding Conductor for Ungrounded Systems

Size of Largest Service Conductor or Equivalent for Multiple Conductors		Size of Grounding Conductor AWG No. or Trade Size (Inch)			
Copper	Aluminum	Copper	Aluminum	Conduit or Pipe	Electrical Metallic Tubing
2 or smaller	0 or smaller	8	6	½	½
1 or 0	2/0 or 3/0	6	4	½	1
2/0 or 3/0	4/0 or 250 MCM	4	2	¾	1¼
Over 3/0 to 350 MCM	Over 250 MCM to 500 MCM	2	0	¾	1¼
Over 350 MCM to 600 MCM	Over 500 MCM to 900 MCM	0	3/0	1	2
Over 600 MCM to 1100 MCM	Over 900 MCM to 1750 MCM	2/0	4/0	1	2
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM	1	2

Table 250-95. Sizes of Conductors for Grounding Interior Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size of Grounding Conductor			
	Copper Wire No.	Aluminum* Wire No.	Conduit or Pipe (Inch)	Electrical Metallic Tubing (Inch)
20	16**	14**	½	½
30	14	12	½	½
40	12	10	½	½
60	10	8	½	½
100	8	6	½	½
200	6	4	½	1
400	3	1	¾	1¼
600	1	00	¾	1¼
800	0	000	1	2
1000	00	0000	1	2
1200***	000	250 MCM	1	2

* See installation restrictions in Section 250-92(a).

** Permissible only when part of an approved cable assembly.

*** For ratings above 1200 amperes, the size of the grounding conductor shall be increased proportionately.

250-96. Portable and Pendant Equipment. For grounding portable or pendant equipment, the conductors of which are protected by fuses or circuit breakers rated or set at not exceeding 20 amperes, No. 18 copper wire may be used. Conductors of Nos. 16 or 18 copper which are used for grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendant equipment protected at more than 20 amperes, Table 250-95 shall be followed.

250-97. Outline Lighting. Isolated noncurrent-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from physical damage, where a conductor complying with Section 250-95 is used to ground the group.

250-98. Common Raceway. A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

250-99. Continuity. No automatic cutout or switch shall be placed in the grounding conductor of an interior wiring system unless the opening of the cutout or switch disconnects all sources of energy.

K. Grounding Conductor Connections

250-111. To Raceway or Cable Armor. The point of connection of the grounding conductor to interior metal raceways, cable armor and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in Section 250-95.

250-112. To Electrode. The grounding connection to the electrode shall be located as follows:

(a) To Water Pipes. System or common grounding conductors shall be attached to a water piping system on the street side of the water meter or on a cold water pipe as near as practicable to the water service entrance to the building. Where the source of the water supply is from a driven well in the basement of the premises, the connection shall be made as near as practicable to the well. Where practicable, the point of attachment shall be accessible. Where the point of attachment is not on the street side of the water meter, the water piping system shall be made electrically continuous by bonding together all parts between the attachment and the street side of the water meter or the pipe entrance which contain insulating sections or are liable to become disconnected, as at meters, valves and service unions.

(b) To Gas Pipes.

The attachment of a grounding conductor to gas piping shall be prohibited. An effective bonding shall be provided for all gas metallic piping within a building.

(c) To Other Electrodes. The grounding conductor shall be attached to other electrodes permitted in Sections 250-82 and 250-83 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

250-113. Attachment to Circuits and Equipment. The grounding conductor, bond, or bonding jumper shall be attached to circuits, conduits, cabinets, equipment, and the like, which are to be grounded, by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used.

250-114. Continuity and Attachment of Branch Circuit Grounding Conductors to Boxes. Where more than one grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

(a) Metallic Boxes. A connection shall be made between the one or more grounding conductors and a metallic box by means of a grounding screw which shall be used for no other purpose, or an approved grounding device.

(b) Nonmetallic Boxes. One or more grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box which requires grounding.

250-115. Attachment to Electrodes. The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or (2) a pipe fitting, plug, or other approved device, screwed into the pipe or into the fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

250-116.

DELETED

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250-118. Clean Surfaces. Where a nonconductive protective coating, such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

L. Instrument Transformers, Relays, etc.

250-121. Instrument Transformer Circuits. The secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and where on switchboards, shall be grounded irrespective of voltage, except that such circuits need not be grounded where the primary windings are connected to circuits of 750 volts or less and no live parts or wiring are exposed or accessible to other than qualified persons.

250-122. Instrument Transformer Cases. Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

250-123. Cases of Instruments, Meters and Relays—Operating Voltage 750 or Less. Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

(a) **Not on Switchboards.** Instruments, meters, and relays not located on switchboards, which operate with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded;

(b) **On Dead Front Switchboards.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded;

(c) On Live Front Switchboards. Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation, shall be provided for the operator where the voltage to ground exceeds 150.

250-124. Cases of Instruments, Meters and Relays—Operating Voltage Over 750. Where instruments, meters and relays have current-carrying parts over 750 volts to ground, they shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards. Their cases shall not be grounded, except as follows:

(a) In electrostatic ground detectors the internal ground segments of the instrument are connected to the instrument case and grounded; the ground detector shall be isolated by elevation.

250-125. Instrument Grounding Conductor. The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12, where of copper or where of other metal, shall have equal conductance. Cases of instrument transformers, instruments, meters and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

M. Lightning Arresters

250-131. On Secondary Services, 750 Volts or Less. Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

250-132. On Primary Circuits. The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected as follows:

(a) Metallic Interconnection. A metallic interconnection may be made to the secondary neutral provided that, in addition to the direct grounding connection at the arrester:

(1) The grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system. However, in urban waterpipe areas where there are at least four waterpipe connections on the neutral and not less than four such connections in each mile of neutral, the metallic interconnection may be made to the secondary neutral with omission of the direct grounding connection at the arrester.

(2) The grounded conductor of the secondary system is part of a multigrounded neutral system, of which the primary neutral has at least four ground connections in each mile of line in addition to a ground at each service.

(b) Through Spark Gap. Where the secondary is not grounded as in Section 250-132(a), but is otherwise grounded as in Sections 250-82 and 250-83, such interconnection, where made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kv, and there shall be at least one other ground on the grounded conductor of the secondary not less than 20 feet distant from the lightning arrester grounding electrode.

(c) By Special Permission. Except as above provided, interconnection of the arrester ground and the secondary neutral may be made only by special permission.

ARTICLE 280 — LIGHTNING ARRESTERS

A. Industrial Stations

280-1. Where Required. Lightning arresters shall be provided in industrial stations in locations where thunderstorms are frequent and adequate protection against lightning is not otherwise provided.

For lightning arresters in hazardous locations, see Articles 500-517.

280-2. Number Required. A lightning arrester shall be connected to each ungrounded overhead conductor entering or leaving the station, except that where there is more than one circuit, a single set of arresters may be installed on the station bus where means are provided to protect circuits that may remain disconnected from the bus.

280-3. Where Connected. The arrester shall be connected on the line side of all connected station apparatus.

B. Other Occupancies

280-11. Utilization Equipment. Lightning arresters installed for the protection of utilization equipment may be installed either inside or outside the building or enclosure containing the equipment to be protected. Arresters, unless isolated by elevation or made otherwise inaccessible to unqualified persons, shall be enclosed, and where the operating voltage of the circuit exceeds 750 volts between conductors they shall be inaccessible to unqualified persons.

Secondary lightning protection devices may reduce damage to wiring and equipment caused by lightning disturbances. (See Section 502-3.)

C. General

280-21. Location—Indoors. Arresters installed indoors shall be located well away from other equipment, passageways and combustible parts of buildings, and where containing oil shall be separated from other equipment by walls meeting the requirements of Section 450-42.

280-22. Location—Outdoors. Where arresters containing oil are located outdoors, provision shall be made to drain away any accumulation of oil.

Oil may be drained away by ditches and drains or the oil may be absorbed and danger of spreading removed by paving the yard with cinders or other absorbent material to a depth of several inches.

280-23. Connections—Size and Material. The connections between the arrester and the line wire or bus, and between arrester and ground shall be of copper wire or cable or the equivalent, and, except as provided on secondary services in Section 250-131, shall not be smaller than No. 6, and shall be made as short and as straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

280-24. Installation. Lightning-protection accessories such as gap electrodes, and choke coils where used, shall have an insulation from ground or from other conductors at least equal to the insulation required at other points of the circuit.

280-25. Switch for Isolating Arrester. Where isolating switches or disconnecting devices are used, they shall withstand, in full open position, a voltage test between live parts 10 per cent in excess of the maximum voltage test they will withstand to ground.

280-26. Grounding. Lightning arresters shall be grounded in the manner prescribed in Article 250.

Chapter 3. Wiring Methods and Materials

ARTICLE 300 — WIRING METHODS — GENERAL REQUIREMENTS

300-1. Scope.

(a) The provisions of Chapter 3 apply to the electrical and mechanical requirements for the various methods of installing fixed electrical conductors for electric light, heat, power, and certain signal systems.

(b) The provisions of this Article shall apply to all wiring installations, except for remote-control, including low voltage relay switching, low-energy power and signal systems as provided in Article 725, and communication systems as provided in Article 800.

(c) On premises where a continuous underground metallic water-piping network system is not available as a grounding electrode, and where it is not practicable otherwise to secure a ground of permanently low resistance, the use of a wiring method which does not employ metal enclosures for the wires is recommended, unless the character or occupancy of the building is such as to require the use of a metal-enclosed wiring system.

(d) The provisions of this Article are not intended to apply to the conductors which form an integral part of equipment such as motors, motor controllers and the like.

300-2. Voltage Limitations. Wiring methods specified in Chapter 3 may be used for voltages not exceeding 600, unless specifically limited in some Article of Chapter 3. They may be used for voltages over 600 where specifically permitted elsewhere in this code.

300-3. Conductors of Different Systems.

(a) Conductors of light and power systems of 600 volts or less may occupy the same enclosure, without regard to whether the individual circuits are alternating-current or direct-current, only where all conductors are insulated for the maximum voltage of any conductor within the enclosure.

(b) Conductors of light and power systems of over 600 volts shall not occupy the same enclosure with conductors of light and power systems of 600 volts or less.

(c) Secondary wiring to electric discharge lamps of 1,000 volts or less, insulated for the secondary voltage involved, may occupy the same fixture enclosure as the branch circuit conductors.

(d) Primary leads of electric discharge lamp ballasts, insulated for the primary voltage of the ballast, when contained within the individual wiring enclosure may occupy the same fixture enclosure as the branch circuit conductors.

(e) Excitation, control, relay and ammeter conductors used in connection with any individual motor or starter may occupy the same enclosure as the motor circuit conductors.

(f) Conductors of signal or radio systems shall not occupy the same enclosure with conductors of light or power systems except as permitted for elevators in Section 620-36; for sound recording in Section 640-6; for remote-control, low-energy power and signal circuits in Sections 725-16 and 725-42; and communication system in Sections 800-3 and 800-21.

300-4. Protection Against Physical Damage. Where subject to physical damage, conductors shall be adequately protected.

300-5. Protection Against Corrosion. Metal raceways, cable armor, boxes, cable sheathing, cabinets, metallic elbows, couplings and fittings shall be of materials suitable for the environment in which they are to be installed.

(a) Ferrous raceways, cable armor, boxes, cable sheathing, cabinets, metallic elbows, couplings and fittings shall be suitably protected against corrosion inside and outside (except threads at joints) by a coating of approved corrosion resistant material such as zinc, cadmium, or enamel. Where protected from corrosion solely by enamel, they shall not be used out of doors or in wet locations as described in (c) below.

(b) Unless made of materials judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or non-ferrous metallic raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

(c) In portions of dairies, laundries, canneries, and other indoor wet locations, and in locations where walls are frequently washed or where there are surfaces of absorbent materials, such as damp paper or wood, the entire wiring system, including all boxes, fittings, conduits and cable used therewith, shall be mounted so that there is at least one-quarter inch air space between it and the wall or supporting surface.

Meat-packing plants, tanneries, hide cellars, casing rooms, glue houses, fertilizer rooms, salt storage, some chemical works, metal refineries, pulp mills, sugar mills, round houses, some stables, and similar locations are judged to be occupancies where severe corrosive conditions are likely to be present.

300-6. Raceways Exposed to Different Temperatures.

(a) Sealing. Where portions of an interior raceway system are exposed to widely different temperatures, as in refrigerating or cold-storage plants, provision shall be made to prevent circulation of air from a warmer to a colder section through the raceway.

(b) Expansion Joints. Expansion joints for runs of raceway shall be provided where required to compensate for thermal expansion and contraction.

300-7. Underground Runs. Conductors run underground shall comply with the provisions of Section 230-32 as far as mechanical protection is concerned.

Underground cable run under a building shall be in a raceway that is extended beyond the outside wall of the building.

300-8. Through Studs, Joists and Rafters.

(a) Where exposed or concealed wiring conductors in insulating tubes or cables are installed through bored holes in studs, joists or similar wood members, holes shall be bored at the approximate centers of wood members, or at least two inches from the nearest edge.

(b) Where there is no objection because of weakening the building structure, metal-clad or nonmetallic sheathed cable, aluminum sheathed cable and Type MI cable may be laid in notches in the studding or joists when the cable at those points is protected against the driving of nails into it by having the notch covered with a steel plate at least 1/16 inch in thickness before building finish is applied.

300-9. Grounding Metal Enclosures. Metal raceways, boxes, cabinets, cable armor and fittings shall be grounded if and as prescribed in Article 250.

300-10. Electrical Continuity of Metal Raceways and Enclosures. Metal raceways, cable armor, and other metal enclosures for conductors, shall be metallically joined together into a continuous electrical conductor, and shall be so connected to all boxes, fittings and cabinets as to provide effective electrical continuity. Raceways and cable assemblies shall be mechanically secured to boxes, fittings, cabinets and other enclosures, except as provided for nonmetallic boxes in Section 370-7.

300-11. Secured in Place. Raceways, cable assemblies, boxes, cabinets and fittings shall be securely fastened in place, unless otherwise provided for specific purposes elsewhere in this Code.

See Article 318 for Continuous Rigid Cable Supports.

300-12. Mechanical Continuity—Raceways and Cables. Raceways and cable assemblies shall be continuous from outlet to outlet and from fitting to fitting.

300-13. Mechanical Continuity—Conductors. Conductors shall be continuous between outlets, devices, etc., and, except as permitted for auxiliary gutters in Section 374-8, and for wireways in Section 362-6, there shall be no splice or tap within a raceway itself.

300-14. Free Length of Conductors at Outlets and Switch Points. At least six inches of free conductor shall be left at each outlet and switch point for the making up of joints or the connection of fixtures or devices, except where conductors are intended to loop without joints through lampholders, receptacles and similar devices.

300-15. Boxes or Fittings. Except as permitted in Sections 336-11 and 410-60 a box or fitting shall be installed at each outlet, switch point, junction point or conductor splice connection joining sections of conduit, electrical metallic tubing or surface metal raceway. A box shall be installed at each outlet, switch point, or conductor splice connection joining sections of metal-clad cable, aluminum sheathed cable, non-metallic sheathed cable or Type MI cable, and at each outlet and switch point of concealed knob-and-tube work.

Exception: Straight through splice joints for MI cable are permitted without a box provided the splice is accessible and a fitting approved for the purpose is used.

300-16. Raceway or Cable to Open or Concealed Wiring.

(a) A box or terminal fitting having a separately bushed hole for each conductor shall be used wherever a change is made from conduit, electrical metallic tubing, nonmetallic sheathed cable, metal-clad cable, aluminum sheathed cable, or Type MI cable and surface metal raceway wiring to open wiring or to concealed knob-and-tube work. A fitting used for this purpose shall contain no taps or splices and shall not be used at fixture outlets.

(b) A bushing may be used in lieu of a box or terminal fitting at ends of conduit or electrical metallic tubing where conductors leave the conduit or tubing behind a switchboard, or where more than 4 conductors leave the conduit or tubing at control apparatus or in similar locations, in which case the conductors shall be bunched, taped and painted with insulating paint. Such a bushing shall be of the insulating type except for lead-covered conductors.

300-17. Number of Conductors in Raceway. In general the percentage of the total interior cross-sectional area of a raceway occupied by conductors shall not be more than will permit a ready installation or withdrawal of the conductors and dissipation of the heat generated without injury to the insulation of the conductors. See the following Sections of this Code: conduit, Section 346-6; electrical metallic tubing, 348-6; flexible metal conduit, 350-3; surface metal raceways, 352-4; underfloor raceways, 354-5; cellular metal floor raceways, 356-5; structural raceways, 357-6; cellular concrete floor raceways, 358-9; wireways, 362-5; auxiliary gutters, 374-5; theatres, 520-5; signs, 600-21(d); elevators, 620-33; and sound recording, 640-3 and 640-4; and Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits, Article 725.

300-18. Inserting Conductors in Raceways.

(a) Raceways shall first be installed as a complete raceway system without conductors, except those raceways exposed and having a removable cover or capping.

(b) As far as possible, conductors shall not be inserted until the interior of the building has been physically protected from the weather, and all mechanical work on the building which is likely to injure the conductors has been completed.

(c) Pull wires, if to be used, shall not be installed until the raceway system is in place.

(d) Cleaning agents or materials used as lubricants that might have a deleterious effect on conductor coverings shall not be used.

300-19. Supporting Conductors in Vertical Raceways.

(a) Conductors in vertical raceways shall be supported at intervals not greater than those specified in the following table:

		Conductors	
		Aluminum	Copper
No. 18 to No. 8	Not Greater than	100 feet	100 feet
No. 6 to No. 0	" " "	200 feet	100 feet
No. 00 to No. 0000	" " "	180 feet	80 feet
211,601 CM to 350,000 CM	" " "	135 feet	60 feet
350,001 CM to 500,000 CM	" " "	120 feet	50 feet
500,001 CM to 750,000 CM	" " "	95 feet	40 feet
Above 750,000 CM	" " "	85 feet	35 feet

(b) One of the following methods of support, or a method of equal effectiveness is recommended:

(1) By clamping devices constructed of or employing insulating wedges inserted in the ends of the conduits. With cables having varnished cambric or thermoplastic insulation it may also be necessary to clamp the conductor.

(2) By inserting boxes at the required intervals in which insulating supports are installed and secured in a satisfactory manner to withstand the weight of the conductors attached thereto, the boxes being provided with covers.

(3) In junction boxes, by deflecting the cables not less than 90 degrees and carrying them horizontally to a distance not less than twice the diameter of the cable, the cables being carried on two or more insulating supports, and additionally secured thereto by tie wires if desired. When this method is used cables shall be supported at intervals not greater than 20 per cent of those mentioned in the preceding tabulation.

300-20. Induced Currents in Metal Enclosures. When conductors carrying alternating current are installed in metal enclosures they shall be so arranged as to avoid heating the surrounding metal by induction. To accomplish this all phase conductors and the neutral, where one is used, shall be grouped together.

When a single conductor of a circuit passes through metal with magnetic properties the inductive effect shall be minimized by:

(1) Cutting slots in the metal between the individual holes through which the individual conductors pass, or

(2) Passing all the conductors in the circuit through an insulating wall sufficiently large for all of the conductors of the circuit.

Exception: In the case of circuits supplying vacuum or electric discharge lighting systems or signs, or X-ray apparatus, the currents carried by the conductors are so small that the inductive heating effect may be ignored where these conductors are placed in metal enclosures or pass through metal.

Aluminum being a nonmagnetic metal, there will be no heating due to eddy currents, however, induced currents will be present. These are not considered of sufficient magnitude to require grouping of conductors or special treatment in passing conductors through aluminum wall sections.

300-21. Prevention of Spread of Fire. Electrical installations shall be so made that the possible spread of fire through fire-stopped partitions, hollow spaces, fire walls or fire partitions, vertical shafts, ventilating or air-handling ducts is reduced to a minimum.

300-22. Wiring in Ventilating and Exhaust Ducts.

(a) Where it is necessary to run a wiring system through air handling ducts or plenum chambers, the wiring method shall be rigid conduit, electrical metallic tubing, flexible steel conduit with lead-covered conductors, Type ACL metal-clad cable with fittings suitable for the location, Type MI mineral insulated-metal sheathed cable, or Type ALS aluminum sheathed cable. The terminals of circuits of such wiring systems shall be so located that it will not be necessary to install motors or control equipment in the ducts, except for temperature and humidity control. Raceways shall not interfere with the operation of automatic fire dampers in ducts.

Exception No. 1. The above provisions shall not apply to integral fan systems specifically approved for the purpose.

Exception No. 2. It is not the intent of this section to include habitable rooms or areas of a building, the prime purpose of which is not air handling. It may, however, include false ceiling space, hollow spaces in the wall, and the like if used for air handling purposes.

Exception No. 3. In ventilating systems used solely for data processing systems the wiring method shall be rigid conduit, electrical metallic tubing, flexible steel conduit with lead-covered conductors, Type ACL metal-clad cable with fittings approved for the purpose, Type MI mineral insulated-metal sheathed cable, Type ALS aluminum sheathed cable, or flexible cords or cables specifically approved as a part of the data processing system, when such cords or cables may be used in conformance with other sections of this code.

(b) No wiring system of any type shall be installed in ducts used for dust, loose stock, vapor removal or ventilation of commercial type cooking equipment.

300-23. Temporary Wiring.

(a) Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all conductors of the temporary circuit by a single operation.

(b) No bare conductors nor earth returns shall be used for the wiring of any temporary circuit.

ARTICLE 310 — CONDUCTORS FOR GENERAL WIRING

310-1. General.

(a) The purpose of this Article is to assure that conductors have mechanical strength, insulation, and ampacity adequate for the particular conditions under which they are to be used.

(b) Conductors shall be insulated, except when covered or bare conductors are specifically permitted in this Code.

(c) The provisions of this Article are not intended to apply to conductors which form an integral part of equipment such as motors, motor controllers, and the like, or which are provided for elsewhere in this Code.

310-2. Application and Construction.

(a) Conductor Application. Conductor insulations as specified in the following Table 310-2(a) may be installed for any of the wiring methods recognized in this Chapter, except as otherwise provided for in the Table or in Section 310-3, or as otherwise specified in this Code. They are suitable for 600 volts unless otherwise specified.

(b) Conductor Construction. Insulated conductors for use at 600 volts or less shall conform to the provisions of Table 310-2(b).

Table 310-2(a). Conductor Application

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Rubber-Covered Fixture Wire Solid or 7-Strand	*RF-1	60°C 140°F	Fixture wiring. Limited to 300 V.
	*RF-2	60°C 140°F	Fixture wiring, and as permitted in Section 310-8.
Rubber-Covered Fixture Wire Flexible Stranding	*FF-1	60°C 140°F	Fixture wiring. Limited to 300 V.
	*FF-2	60°C 140°F	Fixture wiring, and as permitted in Section 310-8.
Heat-Resistant Rubber-Covered Fixture Wire Solid or 7-Strand	*RFH-1	75°C 167°F	Fixture wiring. Limited to 300 V.
	*RFH-2	75°C 167°F	Fixture wiring, and as permitted in Section 310-8.
Heat-Resistant Rubber-Covered Fixture Wire Flexible Stranding	*FFH-1	75°C 167°F	Fixture wiring. Limited to 300 V.
	*FFH-2	75°C 167°F	Fixture wiring, and as permitted in Section 310-8.
Thermoplastic-Covered Fixture Wire—Solid or Stranded	*TF	60°C 140°F	Fixture wiring, and as permitted in Section 310-8, and for circuits as permitted in Article 725.
Thermoplastic-Covered Fixture Wire—Flexible Stranding	*TFF	60°C 140°F	Fixture wiring, and as permitted in Section 310-8, and for circuits as permitted in Article 725.

*Fixture wires are not intended for installation as branch circuit conductors nor for the connection of portable or stationary appliances.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Cotton-Covered, Heat-Resistant, Fixture Wire	*CF	90°C 194°F	Fixture wiring. Limited to 300 V.
Asbestos-Covered Heat-Resistant, Fixture Wire	*AF	150°C 302°F	Fixture wiring. Limited to 300 V. and Indoor Dry Location.
Silicone Rubber Insulated Fixture Wire	*SF-1	200°C 392°F	Fixture wiring. Limited to 300 V.
Solid or 7 Strand	*SF-2	200°C 392°F	Fixture wiring and as permitted in Section 310-8.
Silicone Rubber Insulated Fixture Wire	*SFF-1	150°C 302°F	Fixture wiring. Limited to 300 V.
Flexible Stranding	*SFF-2	150°C 302°F	Fixture wiring and as permitted in Section 310-8.
Code Rubber	R	60°C 140°F	Dry locations.
Heat-Resistant Rubber	RH	75°C 167°F	Dry locations.
Heat Resistant Rubber	RHH	90°C 194°F	Dry locations.
Moisture-Resistant Rubber	RW	60°C 140°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant.
Moisture and Heat Resistant Rubber	RH-RW	60°C 140°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant.
		75°C 167°F	Dry locations. For over 2000 volts, insulation shall be ozone-resistant.
Moisture and Heat Resistant Rubber	RHW	75°C 167°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant.
Latex Rubber	RU	60°C 140°F	Dry locations.

*Fixture wires are not intended for installation as branch circuit conductors nor for the connection of portable or stationary appliances.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Heat Resistant Latex Rubber	RUH	75°C	Dry locations.
Moisture Resistant Latex Rubber	RUW	60°C 140°F	Dry and wet locations.
Thermoplastic	T	60°C 140°F	Dry locations.
Moisture-Resistant Thermoplastic	TW	60°C 140°F	Dry and wet locations.
Heat-Resistant Thermoplastic	THHN	90°C 194°F	Dry locations.
Moisture and Heat-Resistant Thermoplastic	THW	75°C 167°F	Dry and wet locations.
Moisture and Heat-Resistant Thermoplastic	THWN	75°C 167°F	Dry and wet locations.
Thermoplastic and Asbestos	TA	90°C 194°F	Switchboard wiring only.
Thermoplastic and Fibrous Outer Braid	TBS	90°C 194°F	Switchboard wiring only.
Synthetic Heat-Resistant	SIS	90°C 194°F	Switchboard wiring only.
Mineral Insulation (Metal Sheathed)	MI	85°C 185°F	Dry and wet locations with Type O termination fittings.
		250°C 482°F	For special application.
Silicone-Asbestos	SA	90°C 194°F	Dry locations.
		125°C 257°F	For special application.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Fluorinated Ethylene Propylene	FEP or FEPB	90°C 194°F 200°C 392°F	Dry locations. Dry locations—special applications.
Varnished Cambric	V	85°C 185°F	Dry locations only. Smaller than No. 6 by special permission.
Asbestos and Varnished Cambric	AVA	110°C 230°F	Dry locations only.
Asbestos and Varnished Cambric	AVL	110°C 230°F	Dry and wet locations.
Asbestos and Varnished Cambric	AVB	90°C 194°F	Dry locations only.
Asbestos	A	200°C 392°F	Dry locations only. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AA	200°C 392°F	Dry locations only. Open wiring. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AI	125°C 257°F	Dry locations only. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AIA	125°C 257°F	Dry locations only. Open wiring. In raceways, only for leads to or within apparatus.
Paper		85°C 185°F	For underground service conductors, or by special permission.

Table 310-2(b). Conductor Insulations

Trade Name	Type Letter	Insulation	Thickness of Insulation		Outer Covering
Code	R	Code Rubber	14–12	2/64 Inch	*Moisture-resistant, flame-retardant, non-metallic covering
			10	3/64 Inch	
			8–2	4/64 Inch	
			1–4/0	5/64 Inch	
			213–500	6/64 Inch	
			501–1000	7/64 Inch	
			1001–2000	8/64 Inch	
Heat-Resistant	RH RHH	Heat-Resistant Rubber	**14–12	2/64 Inch	*Moisture resistant, flame-retardant, non-metallic covering
			10	3/64 Inch	
			8–2	4/64 Inch	
			1–4/0	5/64 Inch	
			213–500	6/64 Inch	
			501–1000	7/64 Inch	
			1001–2000	8/64 Inch	
Moisture-Resistant	RW	Moisture-Resistant Rubber	14–10	3/64 Inch	*Moisture-resistant, flame-retardant, non-metallic covering
			8–2	4/64 Inch	
			1–4/0	5/64 Inch	
			213–500	6/64 Inch	
			501–1000	7/64 Inch	
			1001–2000	8/64 Inch	
Moisture and Heat-Resistant	RH-RW	Moisture and Heat Resistant Rubber	14–10	3/64 Inch	*Moisture-resistant, flame-retardant, non-metallic covering
			8–2	4/64 Inch	
			1–4/0	5/64 Inch	
			213–500	6/64 Inch	
			501–1000	7/64 Inch	
			1001–2000	8/64 Inch	

*Outer covering is not required over rubber insulations which have been specifically approved for the purpose.

**For 14–12 sizes RHH shall be 3/64 inch thickness insulation.

Table 310-2(b)—Continued

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Moisture and Heat-Resistant	RHW	Moisture and Heat Resistant Rubber	14–10 . . . . . . 3/64 Inch 8–2 . . . . . . 4/64 Inch 1–4/0 . . . . . . 5/64 Inch 213–500 . . . . . . 6/64 Inch 501–1000 . . . . . . 7/64 Inch 1001–2000 . . . . . . 8/64 Inch	*Moisture-resistant, flame retardant, non-metallic covering
Heat-Resistant Latex Rubber	RUH	90% Unmilled, Grainless Rubber	14–10 . . . . . . 18 Mils 8–2 . . . . . . 25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Moisture-Resistant Latex Rubber	RUW	90% Unmilled, Grainless Rubber	14–10 . . . . . . 18 Mils 8–2 . . . . . . 25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Thermoplastic	T	Flame-Retardant, Thermoplastic Compound	14–10 . . . . . . 2 /64 Inch 8 . . . . . . 3 /64 Inch 6–2 . . . . . . 4 /64 Inch 1–4 /0 . . . . . . 5 /64 Inch 213–500 . . . . . . 6 /64 Inch 501–1000 . . . . . . 7 /64 Inch 1001–2000 . . . . . . 8 /64 Inch	None

* Outer covering is not required over rubber insulations which have been specifically approved for the purpose.

Moisture-Resistant Thermoplastic	TW	Flame-Retardant, Moisture-Resistant Thermoplastic	14–10 8 6–2 1–4/0 213–500 501–1000 1001–2000	2/64 Inch 3/64 Inch 4/64 Inch 5/64 Inch 6/64 Inch 7/64 Inch 8/64 Inch	None
Heat-Resistant Thermoplastic	THHN	Flame-Retardant Heat-Resistant Thermoplastic	14–12 10 8–6 4–2 1–4/0 250–500 MCM	15 Mils 20 Mils 30 Mils 40 Mils 50 Mils 60 Mils	Nylon Jacket
Moisture and Heat-Resistant Thermoplastic	THW	Flame-Retardant, Moisture and Heat-Resistant Thermoplastic	14–10 8–2 1–4/0 213–500 501-1000 1001–2000	3/64 Inch 4/64 Inch 5/64 Inch 6/64 Inch 7/64 Inch 8/64 Inch	None
Moisture and Heat-Resistant Thermoplastic	THWN	Flame-Retardant, Moisture and Heat-Resistant Thermoplastic	14–12 10 8–6 4–2 1–4/0 250–500 MCM	15 Mils 20 Mils 30 Mils 40 Mils 50 Mils 60 Mils	Nylon Jacket
Thermoplastic and Asbestos	TA	Thermoplastic and Asbestos	 14–8 6–2 1–4/0	Th'pl'. Asb. 20 Mils 20 Mils 30 Mils 25 Mils 40 Mils 30 Mils	Flame-retardant, non-metallic covering

Table 310-2(b)—Continued

Trade Name	Type Letter	Insulation	Thickness of Insulation		Outer Covering
Thermoplastic and Fibrous Braid	TBS	Thermoplastic	14–10	2/64 Inch	Flame-retardant, non-metallic covering
			8	3/64 Inch	
			6–2	4/64 Inch	
			1–4/0	5/64 Inch	
Synthetic Heat-Resistant	SIS	Heat-Resistant Rubber	14–10	2/64 Inch	None
			8	3/64 Inch	
			6–2	4/64 Inch	
			1–4/0	5/64 Inch	
Mineral-Insulated Metal-Sheathed	MI	Magnesium Oxide	16–4	50 Mils	Copper
			3–250 MCM	55 Mils	
Silicone-Asbestos	SA	Silicone Rubber	14–10	3/64 Inch	Asbestos or glass
			8–2	4/64 Inch	
			1–4/0	5/64 Inch	
			213–500	6/64 Inch	
			501–1000	7/64 Inch	
			1001–2000	8/64 Inch	
Fluorinated Ethylene Propylene	FEP	Fluorinated Ethylene Propylene	14–10	20 Mils	None
			8–2	30 Mils	
	FEPB	Fluorinated Ethylene Propylene	14–8	14 Mils	Glass braid
			6–2	14 Mils	Asbestos braid

Varnished Cambric	V	Varnished Cambric	14–8	3/64 Inch				Non-metallic covering or lead sheath
			6–2	4/64 Inch				
			1–4/0	5/64 Inch				
			213–500	6/64 Inch				
			501–1000	7/64 Inch				
			1001–2000	8/64 Inch				
Asbestos and Varnished Cambric	AVA and AVL	Impregnated Asbestos and Varnished Cambric	(Dimen. in Mils)	1st Asb.	VC	AVA 2nd Asb.	AVL 2nd Asb.	AVA-asbestos braid or glass
			14–8 (solid only)	—	30	20	25	
			14–8	10	30	15	25	AVL-lead sheath
			6–2	15	30	20	25	
			1–4/0	20	30	30	30	
			213–500	25	40	40	40	
			501–1000	30	40	40	40	
			1001–2000	30	50	50	50	
Asbestos and Varnished Cambric	AVB	Impregnated Asbestos and Varnished Cambric		VC	Asb.			
			18–8	30	20			Flame-retardant, cotton braid (switchboard wiring)
			6–2	40	30			
			1–4/0	40	40			
				Asb.	VC	2nd Asb.		
			14–8	10	30	15		Flame-retardant, cotton braid
			6–2	15	30	20		
			1–4/0	20	30	30		
			213–500	25	40	40		
			501–1000	30	40	40		
			1001–2000	30	50	50		

Table 310-2(b)—Continued

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Asbestos	A	Asbestos	14.......................30 Mils 12–8...................40 Mils	Without asbestos braid
Asbestos	AA	Asbestos	14.......................30 Mils 12–8...................30 Mils 6–2.....................40 Mils 1–4 /0..................60 Mils	With asbestos braid or glass
Asbestos	AI	Impregnated Asbestos	14.......................30 Mils 12–8...................40 Mils	Without asbestos braid
Asbestos	AIA	Impregnated Asbestos	Sol. Str. 14.............30 Mils 30 Mils 12–8..........30 Mils 40 Mils 6–2............40 Mils 60 Mils 1–4 /0.........60 Mils 75 Mils 213–500.................90 Mils 501–1000..............105 Mils	With asbestos braid or glass
Paper		Paper		Lead sheath

The non-metallic covering over individual rubber-covered conductors of aluminum sheathed cable and of lead-sheathed or multiple-conductor cable is not required to be flame retardant. For armored cable, see Section 334-2. For non-metallic-sheathed cable, see Section 336-2. For Type UF cable, see Section 339-1. For aluminum sheathed cable, see Section 331-9.

(310-2 continued)

(c) Marking. Insulated wires, cables and cords of all kinds except paper-insulated wire shall have a continuous distinctive marking so that their maker may be readily identified. All wires, cables and cords shall also be plainly tagged or marked as follows:

(1) The maximum working voltage for which the wire was tested or approved. This may be omitted for asbestos-covered switchboard wires.

(2) The words "National Electrical Code Standard," or "NEC Std."

(3) Name of the manufacturing company and, if desired, trade name of the wire.

(4) Month and year when manufactured.

(5) The proper type letter for the particular style of wire or cable as given in the following sections.

(d) Surface Marking. A durable marking on the surface shall be provided at intervals not exceeding 24 inches showing the name of the manufacturer or a significant abbreviation thereof, type letter or letters as specified in Article 310, Table 310-2(b) and Articles 336, 338, and 339, the size Awg. or circular mils and the maximum voltage on the following types of wire and cable rated 600 volts or less:

(1) Single conductor only, rubber insulated and thermoplastic insulated for General Wiring.

(2) Non-Metallic Sheathed Cable.

(3) Service-Entrance Cable.

(4) Underground Feeder and Branch Circuit Cable.

All other types of wire and cable, flexible cords, fixture wires, switchboard wires, and any of the above types with a metallic covering are not required to have a marking on the surface.

(e) Classification. In addition to the type letters specified in Table 310-2(b), the following letters shall apply:

(1) A type letter or letters used alone indicates a single insulated conductor.

(2) The letter "D" used as a suffix indicates a twin wire with two insulated conductors laid parallel under an outer nonmetallic covering.

(3) The letter "M" used as a suffix indicates an assembly of two or more insulated conductors twisted together under an outer nonmetallic covering.

(4) The letter "L" used as a suffix indicates an outer covering of lead.

(5) Voltage. Type letters, when used alone, indicate conductors for use at not more than 600 volts. Conductors for use at higher voltages shall be indicated by adding numerical suffixes to the type letters as follows:

10—for use at not more than 1000 volts.
20—for use at not more than 2000 volts.
30—for use at not more than 3000 volts.
40—for use at not more than 4000 volts.
50—for use at not more than 5000 volts.

The working voltages referred to in the Table are the operating voltages between phases of single and two-phase systems, and three-phase systems with grounded or ungrounded neutral.

(6) All conductors shall be examined and tested at the factory and, if approved, shall be labeled before shipment.

(f) Identification of Insulation. All rubber-insulated conductors and all thermoplastic-insulated conductors, No. 14 and larger, shall have a readily recognizable durable marking to indicate the grade of insulation; except that single-conductor, code-rubber insulated conductors having a lead sheath; and multi-conductor cables, metal-clad cable, and nonmetallic-sheathed cable having code-rubber or nonmoisture-resistant thermoplastic-insulated conductors, need not be so marked.

(g) Identified Conductors. Single insulated conductors of No. 6 or smaller, intended for use as identified conductors of circuits shall have an outer identification of a white or natural gray color. Twin and twisted-pair conductors and three-conductor cables shall have one conductor, and four-conductor cables shall have at least one conductor identified in this manner.

Exception No. 1 — Multiple-conductor varnished cloth insulated cables.

Exception No. 2 — Fixture wires as outlined below.

Exception No. 3 — Mineral insulated-metal sheathed cable.

For fixture wires the identification shall be as above, or by means of (1) stripes, or (2) by the means described in Section 400-13(a), (b), (c), (d) and (e).

For aerial cable the identification shall be as above, or by means of a ridge so located on the exterior of the cable as to identify it.

Wires having their outer covering finished to show a white or natural gray color but having colored tracer threads in the braid, identifying the source of manufacture, are considered as meeting the provisions of this Section.

(h) Single conductors, intended for use as unidentified conductors, and conductors other than the identified conductor in multi-conductor cables, shall be finished to show a color or combination of colors other than, and contrasting with, white or natural gray. The colors contrasting with white or natural gray, may be provided by means of an approved stripe or stripes on black conductors. For identification requirements for conductors larger than No. 6 see Section 200-6(b).

(i) Insulation Thickness—Over 600 volts. The thickness of insulation for conductors for use at over 600 volts shall conform to Tables 310-2 (i-1 thru i-4):

Table 310-2(i) (1)

Thickness of Rubber Insulation for Rubber-Covered Wire and Cable, in 64ths of an Inch

Conductor Size AWG. or MCM	Classification				
	R 10 RH 10 RW 10 RHW 10	R 20 RH 20 RW 20 RHW 20	RW 30† RH-RW 30† RHW 30†	RW 40† RH-RW 40† RHW 40†	RW 50† RH-RW 50† RHW 50†
14-12	4	5	..	..	..
10- 8*	4	5	7	9	10*
6- 2	5	6	8	9	10
1-4/0	6	7	8	9	10
213-500	7	8	9	10	11
501-1000	8	9	9	10	11
1001-2000	9	9	10	11	12

* No. 8 AWG. is the minimum conductor size for 5000 volts operation.

† Shall be of approved ozone-resistant type for operation at voltages over 2000.

Table 310-2(i) (2)

Thickness of Varnished-Cambric Insulation for Single-Conductor Cable, in 64ths of an Inch

Conductor Size AWG or MCM	For Voltages Not Exceeding				
	1000	2000	3000	4000	5000
14	4	..	..	..	..
12	4	5	..	..	..
10	4	5	6	..	..
8-2	4	5	6	7	9
1-4/0	5	6	6	7	9
213-500	6	6	7	8	10
501-1000	7	7	7	8	10
1001-2000	8	8	8	9	10

Table 310-2(i) (3)

Thickness of Varnished-Cambric Insulation for Multiple-Conductor Cable, in 64ths of an Inch

Conductor Size AWG or MCM	For Voltages Not Exceeding									
	1000		2000		3000		4000		5000	
	C	B	C	B	C	B	C	B	C	B
14	4	0	..	..	..	..	..	..	..	..
12	4	0	5	0	..	..	..	..	..	..
10	4	0	5	0	5	2	..	..	..	..
8-2	4	0	5	0	5	2	6	3	6	4
1-4/0	5	0	6	0	6	2	6	3	6	4
213-500	6	0	6	0	6	2	6	3	7	4
501-1000	6	2	6	2	6	3	6	4	7	4
1001-2000	7	2	7	2	7	3	7	4	7	5

The thickness given in columns headed "C" are for the insulation on the individual conductors. Those given in the columns headed "B" are for the thickness of the overall belt of insulation.

Table 310-2(i) (4)

Thickness of Asbestos and Varnished-Cambric Insulation for Single-Conductor Cable, Types AVA, AVB and AVL, in Mils

Conductor AWG or MCM	1st Wall Asbestos	Varnished Cambric					Asbestos 2nd Wall
	For Voltages Not Exceeding						
	1000-5000	1000	2000	3000	4000	5000	1000-5000
14-2	15	45	60	80	100	120	25
1-4/0	20	45	60	80	100	120	30
213-500	25	45	60	80	100	120	40
501-1000	30	45	60	80	100	120	40
1001-2000	30	55	75	95	115	140	50

310-3. Insulating Materials.

(a) The rubber insulations include those made from natural and synthetic rubber, neoprene and other vulcanizable materials.

(b) Thermoplastic insulation may stiffen at temperatures below minus 10°C (14°F) and care should be used in its installation at such temperatures. It may be deformed when subject to pressure; care should be taken in its installation, as for example, at bushings, or points of support. See Section 373-6(b).

310-4. Temperature Limitations. No conductor shall be used under such conditions that its temperature, even when carrying current, will exceed the temperature specified in Table 310-2(a) for the type of insulation involved.

310-5. Wet Locations. Insulated conductors used underground, in concrete slabs or other masonry in direct contact with earth, in wet locations, or where condensation or accumulation of moisture within the raceway is likely to occur, shall be moisture-resistant, rubber-covered (Type RW); moisture- and heat-resistant (Type RH-RW); moisture- and heat-resistant, rubber-covered (Type RHW); moisture-resistant latex rubber (Type RUW); moisture-resistant, thermoplastic-covered (Type TW); moisture- and heat-resistant, thermoplastic-covered (Type THW); moisture- and heat-resistant thermoplastic (Type THWN); lead covered; aluminum sheathed cable (Type ALS); mineral insulated-metal sheathed (Type MI); or of a type approved for the purpose.

Such conductors are not suitable for direct burial in the earth unless of a type specifically approved for the purpose.

310-6. Buried Conductors.

Cables of one or more conductors for direct burial in the earth shall be buried to a depth of at least 18" below finished grade in grass or seeded areas. Where passing under surfaced areas, such as driveways or roadways, they shall be buried to a depth of at least 24", shall be Type USE, except that branch circuit and feeder cable may be Type UF.

Where single conductor cables are installed, all conductors of each service, feeder, sub-feeder or branch circuit, including the neutral conductor, shall be run continuously in the same trench or raceway. Supplementary mechanical protection, such as a covering board, concrete pad, raceway, etc., may be required by the authority enforcing the Code. See Section 339-3(c).

310-7. Corrosive Conditions. Conductors exposed to oils, greases, vapors, gases, fumes, liquids or other substances having a deleterious effect upon the conductor or insulation shall be a type approved for the purpose.

310-8. Minimum Size of Conductors. Conductors, whether solid or stranded, shall not be smaller than No. 14, except for printing press control circuits; as provided for flexible cords in Section 400-7; for fixture wire in Section 410-18; for fractional horsepower motors in Section 430-22; for cranes and hoists in Section 610-14; for elevator control and signal circuits in Section 620-12; and for remote-control, low energy power, low-voltage power and signal circuits in Section 725-13.

310-9. Stranded Conductors. Except when used as bus bars or in Type MI Cable, conductors No. 6 and larger, installed in raceways, shall be stranded.

310-10. Conductors in Multiple. Conductors in sizes 1/0 and larger may be run in multiple provided the arrangement is such as to assure equal division of total current among all conductors involved. All of the multiple conductors shall be of the same length, of the same conductor material, circular-mil area, same insulation type and terminated in the same manner. Where run in separate raceways or cables, the raceways or cables shall have the same physical characteristics.

When conductors are used in multiple, space in enclosures should be given consideration.

310-11. Ampacity Reduction Factors. Where more than three conductors are installed in a raceway or assembled into one or more cables the ampacity of each conductor shall be reduced in accordance with Note 8 to Tables 310-12 through 310-15.

Notes To Tables 310-12 through 310-15.

Ampacity. The maximum, continuous, ampacities of copper conductors are given in Tables 310-12 and 310-13. The ampacities of aluminum conductors are given in Tables 310-14 and 310-15.

1. Explanation of Tables. For explanation of Type Letters, and for recognized size of conductors for the various conductor insulations, see Sections 310-2 and 310-3. For installation requirements, see Section 310-1 through 310-7, and the various Articles of this Code. For flexible cords see Tables 400-9 and 400-11.

2. Application of Tables. For open wiring on insulators and for concealed knob-and-tube work, the allowable ampacities of Tables 310-13 and 310-15 shall be used. For all other recognized wiring methods, the allowable ampacities of Tables 310-12 and 310-14 shall be used, unless otherwise provided in this Code.

3. Aluminum Conductors. For aluminum conductors, the allowable ampacities shall be in accordance with Tables 310-14 and 310-15.

4. Bare Conductors. Where bare conductors are used with insulated conductors, their allowable ampacities shall be limited to that permitted for the insulated conductors of the same size.

5. Type MI Cable. The temperature limitation on which the ampacities of Type MI cable are based, is determined by the insulating materials used in the end seal. Termination fittings incorporating unimpregnated organic insulating materials are limited to 85°C. operation.

6. Ultimate Insulation Temperature. In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of the conductors will be exceeded.

7. Use of Conductors With Higher Operating Temperatures. Where the room temperature is within 10 degrees C of the maximum allowable operating temperature of the insulation, it is desirable to use an insulation with a higher maximum allowable operating temperature; although insulation can be used in a room temperature approaching its maximum allowable operating temperature limit if the current is reduced in accordance with the Correction Factors for different room temperatures.

8. More Than Three Conductors in a Raceway or Cable. Tables 310-12 and 310-14 give the allowable ampacities for not more than three conductors in a raceway or cable. Where the number of conductors in a raceway or cable exceeds three, the allowable ampacity of each conductor shall be reduced as shown in the following Table:

Number of Conductors	Per Cent of Values in Tables 310-12 and 310-14
4 to 6	80
7 to 24	70
25 to 42	60
43 and above	50

Exception No. 1 — When conductors of different systems, as provided *in Section 300-3, are installed in a common raceway the derating factors shown above apply to the number of Power and Lighting (Articles 210, 215, 220 and 230) conductors only.*

Where the number of conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables are stacked or bundled without maintaining spacing as required in Article 318 and are not installed in raceways, the individual ampacity of each conductor shall be reduced as shown in the above table.

Exception No. 2 — The derating factors of Sections 210-23(b) and 220–2 (second paragraph) do not apply when the above derating factors are also required.

9. Application of Type RH-RW Wire. Where Type RH-RW rubber insulated wire is used in wet locations the allowable ampacities shall be that of Column 2 in Tables 310-12 through 310-15. Where used in dry locations the allowable ampacities shall be that of Column 3 in Tables 310-12 through 310-15.

10. Overcurrent Protection. Where the standard ratings and settings of overcurrent devices do not correspond with the ratings and settings allowed for conductors, the next higher standard rating and setting may be used.

Exception — Except as limited in Section 240-5.

11. Neutral Conductor. A neutral conductor which carries only the unbalanced current from other conductors, as in the case of normally balanced circuits of three or more conductors, shall not be counted in determining ampacities as provided for in Note 8.

In a 3-wire circuit consisting of two phase wires and the neutral of a 4-wire, 3-phase WYE connected system, a common conductor carries approximately the same current as the other conductors and is not therefore considered as a neutral conductor.

12. Voltage Drop. The allowable ampacities in Tables 310-12 through 310-15 are based on temperature alone and do not take voltage drop into consideration.

13. Deterioration of Insulation. It should be noted that even the best grades of rubber insulation will deteriorate in time, so eventually will need to be replaced.

14. Aluminum Sheathed Cable. The ampacities of Type ALS cable are determined by the temperature limitation of the insulated conductors incorporated within the cable. Hence the ampacities of aluminum sheathed cable may be determined from the columns in Tables 310-12 and 310-14 applicable to the type of insulated conductors employed within the cable. See Note 9.

Table 310-12. Allowable Ampacities of Insulated Copper Conductors

Not More than Three Conductors in Raceway or Cable or Direct Burial (Based on Room Temperature of 30°C. 86°F.

Size	Temperature Rating of Conductor. See Table 310-2(a)					
AWG MCM	60°C (140°F)	75°C (167°F)	85°–90°C (185°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)
14	15	15	25 †	30	30	30
12	20	20	30 †	35	40	40
10	30	30	40 †	45	50	55
8	40	45	50	60	65	70
6	55	65	70	80	85	95
4	70	85	90	105	115	120
3	80	100	105	120	130	145
2	95	115	120	135	145	165
1	110	130	140	160	170	190
0	125	150	155	190	200	225
00	145	175	185	215	230	250
000	165	200	210	245	265	285
0000	195	230	235	275	310	340
250	215	255	270	315	335	....
300	240	285	300	345	380	....
350	260	310	325	390	420	....
400	280	335	360	420	450	....
500	320	380	405	470	500	....
600	355	420	455	525	545	....
700	385	460	490	560	600	....
750	400	475	500	580	620	....
800	410	490	515	600	640	....
900	435	520	555	....	....	....
1000	455	545	585	680	730	....
1250	495	590	645	....	....	....
1500	520	625	700	785	....	....
1750	545	650	735	....	....	....
2000	560	665	775	840	....	....
CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.						
C. F.						
40 104	.82	.88	.90	.94	.95	....
45 113	.71	.82	.85	.90	.92	....
50 122	.58	.75	.80	.87	.89	....
55 131	.41	.67	.74	.83	.86	....
60 140	....	.58	.67	.79	.83	.91
70 158	....	.35	.52	.71	.76	.87
75 167	....	....	.43	.66	.72	.86
80 176	....	....	.30	.61	.69	.84
90 194	....	....	....	.50	.61	.80
100 212	....	....	....	....	.51	.77
120 248	....	....	....	....	....	.69
140 284	....	....	....	....	....	.59

These ampacities relate only to conductors described in Table 310-2(a).

† The ampacities for Types FEP, FEPB, RHH and THHN conductors for sizes AWG 14, 12 and 10 shall be the same as designated for 75°C conductors in this Table.

Table 310-13. Allowable Ampacities of Insulated Copper Conductors

Single Conductor in Free Air
(Based on Room Temperature of 30° C. 86° F)

Size	Temperature Rating of Conductor. See Table 310-2(a)						
AWG MCM	60°C (140°F)	75°C (167°F)	85°–90°C (185°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	Bare & Covered Conductor
14	20	20	30 †	40	40	45	30
12	25	25	40 †	50	50	55	40
10	40	40	55 †	65	70	75	55
8	55	65	70	85	90	100	70
6	80	95	100	120	125	135	100
4	105	125	135	160	170	180	130
3	120	145	155	180	195	210	150
2	140	170	180	210	225	240	175
1	165	195	210	245	265	280	205
0	195	230	245	285	305	325	235
00	225	265	285	330	355	370	275
000	260	310	330	385	410	430	320
0000	300	360	385	445	475	510	370
250	340	405	425	495	530	....	410
300	375	445	480	555	590	....	460
350	420	505	530	610	655	....	510
400	455	545	575	665	710	....	555
500	515	620	660	765	815	....	630
600	575	690	740	855	910	....	710
700	630	755	815	940	1005	....	780
750	655	785	845	980	1045	....	810
800	680	815	880	1020	1085	....	845
900	730	870	940	....	....	....	905
1000	780	935	1000	1165	1240	....	965
1250	890	1065	1130	....	....	....	....
1500	980	1175	1260	1450	....	....	1215
1750	1070	1280	1370	....	....	....	....
2000	1155	1385	1470	1715	....	....	1405
CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.							
C. F.							
40 104	.82	.88	.90	.94	.95	....	....
45 113	.71	.82	.85	.90	.92	....	....
50 122	.58	.75	.80	.87	.89	....	....
55 131	.41	.67	.74	.83	.86	....	....
60 140	....	.58	.67	.79	.83	.91	....
70 158	....	.35	.52	.71	.76	.87	....
75 167	....	....	.43	.66	.72	.86	....
80 176	....	....	.30	.61	.69	.84	....
90 194	....	....	....	.50	.61	.80	....
100 212	....	....	....	....	.51	.77	....
120 248	....	....	....	....	....	.69	....
140 284	....	....	....	....	....	.59	....

These ampacities relate only to conductors described in Table 310-2(a).

† The ampacities for Types FEP, FEPB, RHH and THHN conductors for sizes AWG 14, 12 and 10 shall be the same as designated for 75°C conductors in this Table.

Table 310-14. Allowable Ampacities of Insulated Aluminum Conductors

Not More than Three Conductors in Raceway or Cable or Direct Burial (Based on Room Temperature of 30°C. 86°F.

Size	Temperature Rating of Conductor. See Table 310-2(a)					
AWG MCM	60°C (140°F)	75°C (167°F)	85°–90°C (185°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)
12	15	15	25 †	25	30	30
10	25	25	30 †	35	40	45
8	30	40	40 †	45	50	55
6	40	50	55	60	65	75
4	55	65	70	80	90	95
3	65	75	80	95	100	115
*2	75	90	95	105	115	130
*1	85	100	110	125	135	150
*0	100	120	125	150	160	180
*00	115	135	145	170	180	200
*000	130	155	165	195	210	225
*0000	155	180	185	215	245	270
250	170	205	215	250	270	....
300	190	230	240	275	305	....
350	210	250	260	310	335	....
400	225	270	290	335	360	....
500	260	310	330	380	405	....
600	285	340	370	425	440	....
700	310	375	395	455	485	....
750	320	385	405	470	500	....
800	330	395	415	485	520	....
900	355	425	455	....	....	....
1000	375	445	480	560	600	....
1250	405	485	530	....	....	....
1500	435	520	580	650	....	....
1750	455	545	615	....	....	....
2000	470	560	650	705	....	....
CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.						
C. F.						
40 104	.82	.88	.90	.94	.95	....
45 113	.71	.82	.85	.90	.92	....
50 122	.58	.75	.80	.87	.89	....
55 131	.41	.67	.74	.83	.86	....
60 140	....	.58	.67	.79	.83	.91
70 158	....	.35	.52	.71	.76	.87
75 167	....	....	.43	.66	.72	.86
80 176	....	....	.30	.61	.69	.84
90 194	....	....	....	.50	.61	.80
100 212	....	....	....	....	.51	.77
120 248	....	....	....	....	....	.69
140 284	....	....	....	....	....	.59

These ampacities relate only to conductors described in Table 310-2(a).

* For three wire, single phase service and sub-service circuits, the allowable ampacity of RH, RH-RW, RHH, RHW, and THW aluminum conductors shall be for sizes #2-100 Amp., #1-110 Amp., #1/0-125 Amp., #2/0-150 Amp., #3/0-170 Amp. and #4/0-200 Amp.

† The ampacities for Types RHH and THHN conductors for sizes AWG 12, 10 and 8 shall be the same as designated for 75°C conductors in this Table.

Table 310-15. Allowable Ampacities of Insulated Aluminum Conductors

Single Conductor in Free Air
(Based on Room Temperature of 30° C. 86° F)

Size	Temperature Rating of Conductor. See Table 310-2(a)						
AWG MCM	60°C (140°F)	75°C (167°F)	85°–90°C (185°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	Bare & Covered Conductor
12	20	20	30†	40	40	45	30
10	30	30	45†	50	55	60	45
8	45	55	55†	65	70	80	55
6	60	75	80	95	100	105	80
4	80	100	105	125	135	140	100
3	95	115	120	140	150	165	115
2	110	135	140	165	175	185	135
1	130	155	165	190	205	220	160
0	150	180	190	220	240	255	185
00	175	210	220	255	275	290	215
000	200	240	255	300	320	335	250
0000	230	280	300	345	370	400	290
250	265	315	330	385	415	....	320
300	290	350	375	435	460	....	360
350	330	395	415	475	510	....	400
400	355	425	450	520	555	....	435
500	405	485	515	595	635	....	490
600	455	545	585	675	720	....	560
700	500	595	645	745	795	....	615
750	515	620	670	775	825	....	640
800	535	645	695	805	855	....	670
900	580	700	750	....	....	....	725
1000	625	750	800	930	990	....	770
1250	710	855	905	....	....	....	....
1500	795	950	1020	1175	....	....	985
1750	875	1050	1125	....	....	....	....
2000	960	1150	1220	1425	....	....	1165
CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.							
C. F.							
40 104	.82	.88	.90	.94	.95	....	....
45 113	.71	.82	.85	.90	.92	....	....
50 122	.58	.75	.80	.87	.89	....	....
55 131	.41	.67	.74	.83	.86	....	....
60 140	....	.58	.67	.79	.83	.91	....
70 158	....	.35	.52	.71	.76	.87	....
75 167	....	....	.43	.66	.72	.86	....
80 176	....	....	.30	.61	.69	.84	....
90 194	....	....	....	.50	.61	.80	....
100 212	....	....	....	....	.51	.77	....
120 248	....	....	....	....	....	.69	....
140 284	....	....	....	....	....	.59	....

These ampacities relate only to conductors described in Table 310-2(a).

† The ampacities for Types RHH and THHN conductors for sizes AWG 12, 10 and 8 shall be the same as designated for 75°C conductors in this Table.

ARTICLE 318 — CONTINUOUS RIGID CABLE SUPPORTS

318-1. Definition. A continuous rigid cable support is a unit or an assembly of units or sections, and associated fittings, made of metal or other noncombustible materials forming a continuous rigid structure used to support cables. Continuous rigid cable supports include ladders, troughs, channels, and other similar structures.

It is not the intent of this Article to require that cables be supported by continuous rigid cable supports or to recognize the use of conductors described in Article 310 in continuous rigid cable supports for general wiring.

318-2. Use.

(a) Continuous rigid cable supports may be used as the mechanical support for only the following wiring methods under the conditions detailed in the Article for each wiring method: (1) Mineral-insulated metal-sheathed cables, (Article 330), (2) Aluminum sheathed cable, (Article 331), (3) Metal-clad cable, (Article 334), (4) Non-metallic sheathed cable, (Article 336), (5) Service entrance cables, (Article 338), (6) Underground feeder and branch circuit cable, (Article 339), (7) Any approved conduit or raceway with its contained conductors.

(b) Continuous rigid cable supports may be used as the mechanical support for factory-assembled, multiconductor control, signal, and power cables, which are specifically approved for installation in Continuous Rigid Cable Supports, in fire-resistive or non-combustible construction, but shall not be used (1) in hoistways, (2) where the cables supported are subject to severe physical damage, (3) in areas having readily combustible contents as determined by the authority enforcing this Code. Continuous Rigid Cable Supports may be used to support cables in hazardous locations when the cables are specifically approved for such use. (Refer to Section 501-4, 502-4, and 503-3.)

318-3. Construction. Continuous Rigid Cable Supports shall be approved for the purpose and shall comply with the following:

(1) Shall have suitable strength and rigidity to provide adequate support for all contained wiring.

(2) Shall not present sharp edges, burrs or projections injurious to the insulation or jackets of the wiring.

(3) If made of metal, shall be adequately protected against corrosion or shall be made of corrosion-resistant material.

(4) Shall have side rails or equivalent structural members.

(5) Shall include fittings for changes in direction and elevation of runs.

318-4. Installation.

(a) Continuous Rigid Cable Supports shall be installed as a complete support system.

(b) Each run of continuous rigid cable support shall be complete before the installation of cables.

(c) Continuous rigid cable supports shall be mechanically connected to any enclosure or raceway into which the cables contained in the continuous rigid cable support extend or terminate.

(d) In portions of runs where additional physical protection is required, noncombustible covers or enclosures providing the required protection shall be used.

(e) Installations involving different electrical systems shall comply with Section 300-3 and, where separation is required, the separation shall be a solid noncombustible partition or compartment. Where cables, as permitted by Section 318-2(b), are installed in the same continuous rigid cable support as the cables permitted by Section 318-2 (a), the requirements of this section shall apply

(f) When continuous rigid cable supports are installed in tiers, the minimum vertical clearance between tiers shall be 12 inches.

(g) Continuous rigid cable supports may extend transversely through partitions or walls, other than fire walls, provided the section of the support within the wall is continuous and unventilated. See Section 300-21.

(h) Continuous rigid cable supports may extend vertically through dry floors and platforms provided the continuous rigid cable support is totally enclosed where it passes through the floor or platform opening and for a distance of six feet above the floor or platform to provide protection from physical injury. See Section 300-21.

(i) Continuous rigid cable supports may extend vertically through floors and platforms in wet locations where (1) there are curbs or other suitable means to prevent water flow through the floor or platform opening and (2) the continuous rigid cable support is totally enclosed where it passes through the floor or platform opening and for a distance of six feet above the floor or platform to provide protection from physical injury. See Section 300-21.

(j) Cable splices and cable taps shall be made only in junction boxes or fittings approved for the purpose.

(k) In other than horizontal runs, and where side rails do not provide adequate containment of the cables, they shall be fastened securely to transverse members of the continuous rigid cable support.

(l) Where continuous rigid cable supports are located adjacent to one another an adequate working space of 24 inches minimum should be maintained on one side of each continuous rigid cable support, or where grouped in rows adjacent to each other a minimum working space of 32 inches should be maintained over each continuous rigid cable support.

(m) A minimum vertical clearance of 6 inches should be maintained from the top of the continuous rigid cable support to all ceilings, beams, and other obstructions.

318-5. Grounding. All metal sections of continuous rigid cable supports and fittings shall be bonded and effectively grounded to provide a continuous circuit for fault current. A continuous rigid cable support system shall not be used either as a grounded circuit conductor or as an equipment grounding conductor. See Section 250-33.

318-6. Ampacity. The ampacities of cables installed in continuous rigid cable supports shall be as follows:

(a) Where cables containing not more than three current-carrying conductors are installed in ventilated continuous rigid cable supports and spacing is maintained at from one-quarter to one cable diameter, the factors of Table 318-6 (a) shall be applied to the ampacities of the cables used.

Table 318-6 (a)
Factors for Cables with Maintained Spacing

Number of Cables	Horizontally					
	1	2	3	4	5	6
Vertically						
1	1.00	0.93	0.87	0.84	0.83	0.82
2	0.89	0.83	0.79	0.76	0.75	0.74
3	0.80	0.76	0.72	0.70	0.69	0.68
4	0.77	0.72	0.68	0.67	0.66	0.65
5	0.75	0.70	0.66	0.65	0.64	0.63
6	0.74	0.69	0.64	0.63	0.62	0.61

(b) The ampacities of cables shall be in accordance with the requirements of Note 8 of Notes to Tables 310-12 through 310-15 where (1) cables are not spaced, (2) spacing is maintained between cables of more than three current-carrying conductors, or (3) unventilated continuous rigid cable supports are used.

ARTICLE 320 — OPEN WIRING ON INSULATORS

320-1. Definition. Open wiring is a wiring method using cleats, knobs, tubes and flexible tubing for the protection and support of insulated conductors run in or on buildings, and not concealed by the building structure.

320-2. Use.

(a) Open wiring on insulators may be used for exposed work, either inside or outside building; in dry or wet locations; where subject to corrosive vapors such as covered by Article 480; for services as covered by Article 230, provided the requirements of this Article are satisfied.

(b) Open wiring on insulators shall not be used (1) in commercial garages, (2) in theaters, (3) in motion-picture studios, (4) in hoistways, and (5) in hazardous locations, except in storage compartments of Class III locations as provided in Section 503-3(b).

320-3. Other Articles. In addition to the provisions of this Article, open wiring shall conform to the other applicable provisions of this Code. See especially Articles 300 and 730.

320-4. Conductors. The type of conductors shall conform to Article 310. Only single conductors shall be used.

(a) The allowable ampacities of insulated conductors as shown in Article 310 shall apply to open wiring on insulators.

320-5. Supports.

(a) Conductors shall not be in contact with any object other than their insulating supports. They shall be rigidly supported on noncombustible, nonabsorptive insulating material as follows:

(1) Under ordinary circumstances, supports for wiring over flat surfaces shall be not more than 4½ feet apart. Where the conductors are likely to be disturbed, the distance between supports shall be shortened sufficiently to provide adequate support for conductors;

(2) Conductors shall be supported within 6 inches of a tap;

(3) Conductors shall not be dead ended at a rosette, lampholder, or receptacle unless the last support is within 12 inches of the device.

(b) The following exceptions to the provisions of Section 320-5(a) may be permitted:

Exception No. 1. For use of nonmetallic flexible tubing, see Section 320-7.

Exception No. 2. Conductors of No. 8 or larger installed in the open across open spaces where not likely to be disturbed, may be supported at distances not greater than 15 feet provided that approved noncombustible, nonabsorptive insulating separators assuring not less than 2½-inch separation between conductors, are installed at intervals of not over 4½ feet.

Exception No. 3. In buildings of mill construction where not likely to be disturbed, feeders in the open, not smaller than No. 8, may be separated about six inches and installed direct from timber to timber, being supported from each timber only.

(c) When nails are used to mount knobs they shall not be smaller than 10 penny. When screws are used to mount knobs, or when nails or screws are used to mount cleats, they shall be of a length sufficient to penetrate the wood to a depth equal to at least one-half the height of the knob and fully the thickness of the cleat. Cushion washers shall be used with nails.

320-6. Conductor Separation. Open conductors shall be separated as follows:

(a) For voltage not exceeding 300 volts between conductors, 2½ inches from each other and shall be separated from the surface wired over at least ½ inch in dry locations.

(b) For voltages of 301 to 600 volts between conductors, 4 inches from each other and shall be separated from surface wired over at least 1 inch.

(c) In damp or wet locations, a separation of at least 1 inch from the surface wired over shall be maintained for all voltages.

320-7. Flexible Nonmetallic Tubing. In dry locations, when not exposed to severe physical damage, conductors may be separately encased in flexible tubing. Tubing shall be in continuous length not exceeding 15 feet, and secured to the surface wired over by straps spaced not exceeding 4½ feet apart.

320-8. Tie Wires. No. 8 or larger conductors supported on solid knobs shall be securely tied thereto. Tie wires shall have a covering equivalent to conductors which they confine.

320-9. Passing Through Walls and Floors. Open conductors shall be separated from contact with walls, floors, timbers or partitions through which they pass by tubes or bushings of noncombustible, nonabsorptive insulating material. Where the bushing is shorter than the hole, a waterproof sleeve of noninductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at either end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor must be carried through a separate tube or sleeve.

320-10. Separation from Metal Work. Open conductors shall be separated at least 2 inches from metallic conduit, piping, or other conducting material, and from any exposed lighting, power or signal conductor, or shall be separated therefrom by a continuous and firmly fixed nonconductor additional to the insulation of the conductor. Where any insulating tube is used, it shall be secured at the ends. Deviation from this requirement may, when necessary, be allowed by the authority enforcing this Code.

320-11. Separation from Piping in Damp Locations. Open conductors located close to water pipes or tanks, or in other damp locations, shall be so placed that an air space will be permanently maintained between them and pipes which they cross. Where practicable, conductors shall be installed over, rather than under, pipes upon which moisture is likely to gather or which may leak.

320-12. Protection from Physical Damage. Where open conductors cross ceiling joists and wall studs, and are exposed to physical damage, they shall be protected by one of the following methods. Conductors within 7 feet from the floor shall be considered exposed to physical damage.

(a) By guard strips not less than ⅞ inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring.

(b) By a substantial running board at least ½ inch thick back of the conductors with side protections. Running boards shall extend at least 1 inch outside the conductors, but not more than 2 inches and the protecting sides shall be at least 2 inches high and at least ⅞ inch thick.

(c) By boxing made as above and furnished with cover kept at least 1 inch away from the conductors within. Where protecting vertical conductors on side walls the boxing shall be closed at the top and the holes through which the conductors pass shall be bushed.

(d) By rigid metal conduit or electrical metallic tubing, in which case the rules of Articles 346 or 348 shall apply; or by metal piping, in which case the conductors shall be encased in continuous lengths of approved flexible tubing. The conductors passing through metal enclosures shall be so grouped that current in both directions is approximately equal.

320-13. In Accessible Attics. Conductors in unfinished attics or roof spaces shall be installed in accordance with the provisions of Section 324-8.

320-14. Entering Spaces Subject to Dampness, Wetness or Corrosive Vapors. Conductors entering or leaving locations subject to dampness, wetness or corrosive vapors shall have drip loops formed on them and shall then pass upward and inward from the outside of buildings, or from the damp, wet, or corrosive location, through noncombustible, nonabsorptive insulating tubes. See also Sections 230-49 and 730-21.

320-15. Switches.

(a) Surface-type snap switches shall be mounted in accordance with the provisions of Section 380-10. Metal boxes are not required. See Section 380-3.

(b) Other types of switches shall be installed in accordance with the provisions of Section 380-3.

ARTICLE 324 — CONCEALED KNOB-AND-TUBE WORK

324-1. Definition. Concealed knob-and-tube wiring is a wiring method using knobs, tubes and flexible nonmetallic tubing for the protection and support of insulated conductors concealed in hollow spaces of walls and ceilings of buildings.

324-2. Use. Concealed knob-and-tube work may be used in the hollow spaces of walls and ceilings. It shall not be used (1) in commercial garages, (2) in theaters, except as provided in Section 520-4, (3) in motion-picture studios, nor (4) in hazardous locations.

324-3. Other Articles. In addition to the provisions of this Article, concealed knob-and-tube wiring shall conform to the other applicable provisions of this Code. See especially Article 300.

324-4. Conductors. Only single conductors shall be used. The ampacity and type of conductor shall conform to Article 310.

324-5. Supports. Conductors shall be supported at intervals not exceeding 4½ feet by knobs or tubes of noncombustible, nonabsorptive, insulating material. There shall be a knob within 6 inches from each tap. Tie wires shall comply with Section 320-8. Where such support is impracticable and the conductors are in a dry location, they may be fished when separately enclosed in flexible nonmetallic tubing extending in continuous lengths from one support to the next or to a box, or from one box to another.

324-6. Conductor Separation.

(a) Conductors shall be separated at least 3 inches and maintained at least 1 inch from the surface wired over.

(b) At distributing centers, meters, outlets, switches or other places where space is limited and the 3-inch separation cannot be maintained, each conductor shall be encased in a continuous length of flexible tubing.

(c) Where practicable, conductors shall be run singly on separate timbers or studding.

324-7. Separation from Other Objects and Protection. Conductors shall be separated from other conductors and objects as follows:

(a) The provisions as to rigid supporting and clearance from foreign wires and other objects, as specified for open wiring in Sections 320-9, 320-10, 320-11, and 320-15, shall be complied with.

(b) Conductors passing through cross timbers in plastered partitions shall be protected by an additional noncombustible, nonabsorptive insulating tube extending at least 3 inches above the timber.

324-8. In Unfinished Attics and Roof Spaces. Conductors in unfinished attics or roof spaces shall comply with the following:

(a) Conductors in unfinished attics and roof spaces shall be run through or on the sides of joists, studs and rafters, except in attics and roof spaces having head room at all points of less than 3 feet in buildings completed before the wiring is installed.

(b) Where conductors in accessible unfinished attics or roof spaces reached by stairway or permanent ladder are run through bored holes in floor joists or through bored holes in studs or rafters within 7 feet of the floor or floor joists, such conductors shall be protected by substantial running boards extending at least 1 inch on each side of the conductors and securely fastened in place.

(c) Where carried along the sides of rafters, studs or floor joists, neither running boards nor guard strips will be required.

324-9. Boxes of Insulating Material. Nonmetallic outlet boxes may be used as provided in Sections 370-3 and 370-7.

324-10. Switches. See Sections 380-3 and 380-10.

ARTICLE 328 — BARE-CONDUCTOR FEEDERS

328-1. Use. By special permission, bare conductors installed in accordance with the provisions of Sections 300-1 to 300-22 inclusive and in accordance with the provisions of the following Sections 328-2 to 328-7 inclusive may be used for feeders only. Such bare conductors may be installed only in a chase, channel or shaft of noncombustible material in a building of fire-resistive construction; and only where the voltage between conductors does not exceed 600 volts. Bare conductors shall not be used in damp or wet locations, nor in any hazardous location, nor where subject to corrosive vapor, except in storage-battery rooms as provided in Section 480-7.

328-2. Size and Capacity of Copper Conductors. The maximum permissible current shall be 1000 amperes per square inch of cross-sectional area of conductor in unventilated enclosures, and 1200 amperes per square inch in ventilated enclosures. These provisions are not intended to apply to equipment such as controls and switchgear.

328-3. Branch Taps. Branch taps from bare-conductor feeders may be installed as specified in Section 240-15; provided that the mechanical protection specified by Exceptions No. 5 and 6 of Section 240-15 shall not be required for that portion of the conductor located in the chase, channel or shaft.

328-4. Accessibility. The conductors shall not be accessible to other than qualified persons.

328-5. Supports. Conductors shall be supported as follows:

(a) Conductors shall be supported on noncombustible, nonabsorptive insulating supports of adequate mechanical strength.

(b) Conductors shall be so supported that a separation between conductors, and between conductors and ground, of not less than that specified in Section 384-26 will be maintained under all conditions of operation.

328-6. Fire Cutoffs. Where floors are pierced, suitable cutoffs against vertical travel of fire shall be provided. See also Section 300-21.

328-7. Special Safeguards. In addition to the provisions of the preceding sections, the authority enforcing this Code may require other safeguards in view of special conditions that may be met in a particular installation.

ARTICLE 330 — MINERAL INSULATED-METAL SHEATHED CABLE

Type MI

A. General

330-1. Definition and Construction. For the purpose of this Article, mineral insulated-metal sheathed Type MI cable is a cable in which one or more electrical conductors are insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight metallic tube sheathing. It shall be used with approved fittings for terminating and connecting to boxes, outlets and other equipment.

330-2. Use. Mineral insulated-metal sheathed cable may be used for services, feeders and branch circuits in both exposed and concealed work, in dry or wet locations; in Class I, Class II, and Class III hazardous locations as noted in the appropriate Articles; for under plaster extensions as provided in Article 344; and embedded in plaster finish on brick or other masonry. It may be used where exposed to weather or continuous moisture, for underground runs and embedded in masonry, concrete or fill, in buildings in course of construction or where exposed to oil, gasoline, or other conditions not having a deteriorating effect on the metal sheath. The sheath of mineral insulated-metal sheathed cable exposed to destructive corrosive conditions, such as some types of cinder fill, shall be protected by materials suitable for those conditions.

330-3. Other Articles. In addition to the provisions of this Article, the installation of mineral insulated-metal sheathed cable shall comply with the other applicable provisions of this Code. See especially Article 300.

B. Installation

330-4. Supports. Mineral insulated-metal sheathed cable shall be securely supported by approved staples, straps, hangers or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured at intervals not exceeding 6 feet except where cable is fished.

330-5. Through Studs, Joists and Rafters. See Section 300-8.

330-6. Wet Locations. See Section 300-5.

330-7. Bends. All bends shall be so made that the cable will not be damaged and the radius of the curve of the inner edge of any bend shall be not less than 5 times the diameter of the cable.

330-8. Terminating Seal. At all points where mineral insulated-metal sheathed cable terminates an approved seal shall be provided immediately after stripping to prevent entrance of moisture into the mineral insulation. The conductors extending beyond the sheath shall be insulated with an approved insulating material.

330-9. Fittings. When Type MI cable is connected to boxes or equipment, the fittings shall be approved for the conditions of service. When single conductor Type MI cables enter metal boxes through separate openings, refer to Section 300-20.

330-10. Insulation Resistance. The completed wiring system shall be tested for insulation resistance in accordance with Section 110-20.

C. Construction Specifications

330-11. General. Type MI Cable for 600 volts shall conform to the following:

(a) Conductors. The conductors are solid copper and have cross sectional areas corresponding to the standard American Wire Gage sizes.

(b) Insulation. The insulation is a highly compressed refractory mineral which provides proper spacing for the conductors.

(c) Outer Sheath. The outer sheath shall be of a continuous copper construction to provide mechanical protection and a moisture seal, and an adequate path for grounding purposes.

ARTICLE 331 — ALUMINUM SHEATHED CABLE

Type ALS

A. General

331-1. Definition and Construction. Aluminum sheathed type ALS cable is a factory assembled cable consisting of one or more insulated conductors enclosed in an impervious, continuous, closely fitting tube of aluminum. It shall be used with approved fittings for terminating and connecting to boxes, outlets and other equipment.

331-2. Use. Aluminum sheathed cable may be used in both exposed and concealed work, in dry or wet locations. The sheath of aluminum sheathed cable exposed to destructive corrosive conditions such as environments containing strong chlorides or caustic alkalis, or where vapors of chlorine or hydrochloric acid are present or where the cable is installed underground, shall be protected by materials suitable for those conditions. See Section 300-5.

Aluminum sheathed cable and fittings shall not be embedded or buried directly in concrete or used in areas subject to severe corrosive influences unless suitable supplemental corrosion protection is provided.

See Section 310-6.

331-3. Other Articles. In addition to the provisions of this Article, the installation of aluminum sheathed cable shall comply with the other applicable provisions of this Code. See especially Article 300.

B. Installations

331-4. Supports. Aluminum sheathed cable shall be securely supported by staples, straps, hangers, or similar fittings so designed and installed as not to injure the cable. Cable shall be secured at intervals not exceeding 6 feet except where the cable is fished.

331-5. Through Studs, Joists and Rafters. See Section 300-8.

331-6. Wet Locations. See Section 300-5.

331-7. Bends. All bends shall be so made that the cable will not be damaged and the radius of the curve on the inner edge of any bend shall be not less than:

(a) Ten times the external diameter of the sheath for cable not more than ¾ inch in external diameter.

(b) Twelve times the external diameter of the sheath for cable more than ¾ inch but not more than 1½ inches in external diameter; and

(c) Fifteen times the external diameter of the sheath for cable more than 1½ inches in external diameter.

331-8. Fittings. When aluminum sheathed cable is connected to boxes or equipment, the fittings shall be approved for the conditions of service. When single conductor aluminum sheathed cables enter metal boxes through separate openings refer to Section 300-20.

C. Construction

331-9. General. Type ALS cable shall conform to the following:

(a) Conductors. The conductors shall be copper or electrical conductor (EC) grade aluminum, solid or stranded.

(b) Insulation. The insulation shall be a type listed in Table 310-2(b).

(c) Insulation Covering. The covering over the insulation shall be the same as permitted for lead sheathed cable or multiple conductor cable.

(d) Outer Sheath. The outer sheath shall be of a continuous, closely fitting tube of aluminum to provide mechanical protection, a moisture seal and an adequate path for equipment grounding purposes and shall conform with provisions of Section 331-2. The sheath shall not be used as a current-carrying conductor.

ARTICLE 334 — METAL-CLAD CABLE

Type MC and AC Series

334-1. Definition. A metal-clad cable is a fabricated assembly of insulated conductors in a flexible metallic enclosure. See Section 334-4.

334-2. Voltage. See Section 300-2. For systems in excess of 600 volts see Article 710.

334-3. Marking. The provisions of Section 310-2 shall apply, except that AC cable shall have ready identification of the maker by distinctive external markers in the cable sheath throughout its entire length.

334-4. Construction. Metal-clad cable shall be an approved cable of Type MC or AC Series, with acceptable metal covering. The insulated conductors shall conform with Section 334-5.

(a) Type MC. Type MC cables are power cables limited in size, for the voltages of this article, to conductors of No. 4 AWG and larger for copper and No. 2 AWG and larger for aluminum. The metal enclosures shall be either a covering of interlocking metal tape, or an impervious, close fitting, corrugated tube. Supplemental protection of an outer covering of corrosion-resistant material shall be required where such protection is needed. See Section 300-5. The cables shall provide adequate path for grounding purposes.

(b) Type AC. Type AC cables are branch circuit and feeder cables with armor of flexible metal tape. Cables of the AC type, except ACL, shall have an internal bonding strip of copper or aluminum, in intimate contact with the armor for its entire length.

334-5. Conductors. Conductors for metal-clad cable shall conform with the following:

(a) Type MC. For cables of Type MC, insulated conductors shall be of a type listed in Table 310-2(b) for rubber, thermoplastic, varnished cloth, asbestos-varnished cloth, or of a type especially approved for the purpose.

(b) Type AC. For cables of Type AC, insulated conductors shall be of a type listed in Table 310-2(b). In addition, the conductors shall have an over-all moisture-resistant and fire-retardant fibrous covering; for Type ACT, a moisture-resistant fibrous covering is required only on the individual conductors.

334-6. Use. Except where otherwise specified elsewhere in this Code, and where not subject to physical damage, metal-clad cable may be installed for branch circuits and feeders in both exposed and concealed work as follows:

(a) Type MC. This type of power cable may be used in partially protected areas, such as in continuous rigid cable supports and the like, in dry locations and when any of the following conditions are met it may be used in wet locations:

(1) The metallic covering is impervious to moisture.

(2) A lead sheath or moisture impervious jacket is provided under the metal covering.

(3) The insulated conductors under the metallic covering are approved for use in wet locations.

See Section 300-5.

(b) Type AC. Metal-clad cable of the AC type may be used in dry locations; for under plaster extensions as provided in Article 344; and embedded in plaster finish on brick or other masonry, except in damp or wet locations. This cable may be run or fished in the air voids of masonry block or tile walls; where such walls are exposed or subject to excessive moisture or dampness or are below grade line, Type ACL cable shall be used. This cable shall contain lead-covered conductors (Type ACL), if used where exposed to the weather or to continuous moisture, for underground runs and embedded in masonry, concrete or fill in buildings in course of construction, or where exposed to oil, or other conditions having a deteriorating effect on the insulation. Type AC metal-clad cable shall not be used where prohibited elsewhere in this Code, including (1) in theatres, except as provided in Section 520-4; (2) in motion-picture studios; (3) in any hazardous locations; (4) where exposed to corrosive fumes or vapors; (5) on cranes or hoists, except as provided in Section 610-11 Exception No. 3; (6) in storage battery rooms; (7) in hoistways or on elevators, except as provided in Section 620-21; or (8) commercial garages where prohibited in Article 511.

334-7. Other Articles. In addition to the provision of this Article, metal-clad cable shall conform to other applicable provisions of this Code. See especially Article 300.

334-8. Supports. Metal-clad cable shall be secured by approved staples, straps, hangers or similar fittings so designed and installed as not to injure the cable.

(a) Type MC cable shall be secured at intervals not exceeding six feet, and within two feet from every box or fitting, except where cable is fished. Cable may be installed on metal racks, trays, troughs, or continuous rigid cable supports grounded as required by Article 250. The cables shall be separated from each other by a distance of not less than one-quarter of a cable diameter. There shall be no more than one layer of cables on a rack or other support member; each cable so installed shall be supported at intervals not exceeding six feet and within two feet from every box or fitting, and each cable shall be attached to the support at intervals of not more than ten feet horizontally and two feet vertically.

(b) Type AC cable shall be secured at intervals of not exceeding 4½ feet and within 12 inches from every outlet box or fitting, except where cable is fished and except lengths of not over 24 inches at terminals where flexibility is necessary.

334-9. Bends. All bends shall be so made that the cable will not be injured, and the radius of the curve of the inner edge of any bend shall not be less than 7 times the diameter of Type MC cable nor 5 times the diameter of Type AC cable.

334-10. Boxes and Fittings.

(a) At all points where Type MC metal-clad cable terminates, suitable fittings designed for use with the particular wiring cable and the conditions of service, shall be used.

(b) At all points where the armor of AC cable terminates, a fitting shall be provided to protect wires from abrasion, unless the design of the outlet boxes or fittings is such as to afford equivalent protection, and in addition, an approved insulating bushing or its equivalent approved protection shall be provided between the conductors and the armor. The connector or clamp by which the metal-clad cable is fastened to boxes or cabinets shall be of such design that the insulating bushing or its equivalent will be visible for inspection. This bushing is not required with lead-covered cables which shall be so installed that the lead sheath will be visible for inspection. Where change is made from metal-clad cable to other cable or raceway wiring methods, a box shall be installed at junction point as required in Section 300-15.

334-11. Through Studs, Joists and Rafters. See Section 300-8.

334-12. Exposed Work. Exposed runs of cable shall closely follow the surface of the building finish or of running boards, except:

(a) Lengths of not more than 24 inches at terminals where flexibility is necessary.

(b) Where suitably supported in accordance with Section 334-8(a).

(c) On the underside of floor joists in basements where supported at each joist and so located as not to be subject to physical damage.

334-13. In Accessible Attics. Type AC cables in accessible attics or roof spaces shall be installed as follows:

(a) Where run across the top of floor joists, or within 7 feet of floor or floor joists across the face of rafters or studding, in attics and roof spaces which are accessible, the cable shall be protected by substantial guard strips which are at least as high as the cable. Where this space is not accessible by permanent stairs or ladders, protection will only be required within 6 feet of the nearest edge of scuttle hole or attic entrance.

(b) Where cable is carried along the sides of rafters, studs or floor joists, neither guard strips nor running boards shall be required.

ARTICLE 336 — NONMETALLIC SHEATHED CABLE

Types NM and NMC

336-1. Definition. A nonmetallic sheathed cable is an assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material.

336-2. Construction.

Non-metallic sheathed cable shall be an approved Type NM or NMC in sizes No. 14 through 2 AWG with copper conductors and in sizes No. 12 through 2 AWG with aluminum conductors.

(a) Type NM. The conductors shall comply with the requirements for the type of conductor used. Over-all fibrous coverings shall have a flame-retardant and moisture-resistant finish.

(b) Type NMC. The cable shall be of a type approved for the purpose. The over-all covering shall be flame-retardant, moisture-resistant, fungus-resistant and corrosion-resistant.

(c) Marking. In addition to the provisions of Section 310-2, the cable shall have a distinctive marking on the exterior for its entire length specifying cable type.

336-3. Use. Nonmetallic sheathed cable may be installed for both exposed and concealed work as follows:

(a) Type NM. This type of nonmetallic sheathed cable may be installed for both exposed and concealed work in normally dry locations. It may be installed or fished in air voids in masonry block or tile walls where such walls are not exposed or subject to excessive moisture or dampness. Type NM cable shall not be installed where exposed to corrosive fumes or vapors; nor shall it be imbedded in masonry, concrete, fill or plaster; nor run in shallow chase in masonry or concrete and covered with plaster or similar finish.

(b) Moisture and Corrosion-Resistant Type NMC. This type of nonmetallic sheathed cable may be installed for both exposed and concealed work in dry, moist, damp or corrosive locations, and in outside and inside walls of masonry block or tile. Where embedded in plaster or run in a shallow chase in masonry walls and covered with plaster within 2 inches of the finished surface, it shall be protected against damage from nails by a cover of corrosion-resistant coated steel at least 1/16 inch in thickness and ¾ inch wide in the chase or under the final surface finish.

(c) Uses Not Permissible for Either Type NM or NMC Nonmetallic Sheathed Cable. These types shall not be used as: (1) service-entrance cable, (2) in commercial garages, (3) in theatres except as provided in Section 520-4, (4) in motion picture studios, (5) in storage battery rooms, (6) in hoistways, (7) in any hazardous location, (8) embedded in poured cement, concrete or aggregate.

336-4. Other Articles. In addition to the provisions of this Article, installations of nonmetallic sheathed cable shall conform to the other applicable provisions of this Code. See especially Article 300.

336-5. Supports. Nonmetallic sheathed cable shall be secured by approved staples, straps, or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured in place at intervals not exceeding 4½ feet and within 12 inches from every cabinet, box or fitting, except that in concealed work in finished buildings or finished panels for prefabricated buildings where such supporting is impracticable, the cable may be fished between points of access.

336-6. Exposed Work — General. In exposed work, except as provided in Sections 336-8 and 336-9, the cable shall be installed as follows:

(a) The cable shall closely follow the surface of the building finish or of running boards.

(b) It shall be protected from physical damage where necessary, by conduit, pipe, guard strips or other means. Where passing through a floor the cable shall be enclosed in rigid metal conduit or metal pipe extending at least 6 inches above the floor.

336-7. Through Studs, Joists and Rafters. See Section 300-8.

336-8. In Unfinished Basements. Where the cable is run at angles with joists in unfinished basements, assemblies not smaller than two No. 6 or three No. 8 conductors may be secured directly to the lower edges of the joists; smaller assemblies shall either be run through bored holes in the joists or on running boards. Where run parallel to joists, cable of any size shall be secured to the sides or face of the joists.

336-9. In Accessible Attics. Cable in accessible attics or roof spaces shall also conform with Section 334-13.

336-10. Bends. Bends in cable shall be so made, and other handling shall be such, that the protective coverings of the cable will not be injured, and no bend shall have a radius less than 5 times the diameter of the cable.

336-11. Devices of Insulating Material. Switch, outlet, and tap devices of insulating material may be used without boxes in exposed cable wiring, and for concealed work for rewiring in existing buildings where the cable is concealed and fished. Openings in such devices shall form a close fit around the outer covering of the cable and the device shall fully enclose that part of the cable from which any part of the covering has been removed.

Where connections to conductors are by binding screw terminals, there shall be available as many terminals as conductors, unless cables are clamped within the structure and terminals are of a type approved for multiple conductors.

336-12. Boxes of Insulating Material. Nonmetallic outlet boxes approved for the purpose may be used as provided in Section 370-3.

ARTICLE 338 — SERVICE-ENTRANCE CABLE

Types SE and USE

338-1. Definition. Service-entrance cable is a conductor assembly provided with a suitable over-all covering, primarily used for services and of the following types. When consisting of two or more conductors, one may be without individual insulation.

(a) Type SE, having a flame-retardant, moisture-resistant covering, but not required to have inherent protection against mechanical abuse.

(b) Type USE, recognized for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering or inherent protection against mechanical abuse.

338-2. Use as Service-Entrance Conductors. Service-entrance cable used as service-entrance conductors shall be installed as required by Article 230.

338-3. Use as Branch Circuit or Feeders.

(a) Service-entrance cables may be used in interior wiring systems where all of the *circuit* conductors of the cable are of the rubber-covered or thermoplastic type.

(b) Service entrance cables without individual insulation on the grounded circuit conductor shall not be used as a branch circuit or as a feeder within a building, except a cable which has a final nonmetallic outer covering and when supplied by alternating current at not exceeding 150 volts to ground, may be used: (1) As a branch circuit to supply only a range, wall-mounted oven, counter-mounted cooking unit, or clothes dryer, or (2) as a feeder to supply only other buildings on the same premises. It shall not be used as a feeder terminating within the same building in which it originates.

The above provisions do not intend to deny the use of service entrance cable for interior use when the fully insulated conductors are used for circuit wiring and the uninsulated conductor is used for equipment grounding purposes.

(c) Service-entrance cable used to supply appliances shall not be subject to conductor temperatures in excess of the temperature specified for the type of insulation involved.

338-4. Installation Methods.

(a) In addition to the provisions of this Article, service-entrance cable used for interior wiring shall comply with the applicable provisions of Article 300.

(b) Unarmored cable shall be installed in accordance with the applicable provisions of Article 336.

(c) Cables through studs, joists and rafters shall be installed as required in Section 300-8.

338-5. Marking. Service-entrance cable shall conform with the marking required in Section 310-2. Cable with the neutral conductor smaller than the ungrounded conductors shall be so marked.

ARTICLE 339 — UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE

Type UF

339-1. Description and Marking.

(a) Description. Underground feeder and branch circuit cable shall be an approved Type UF cable in sizes No. 14 to No. 4/0 AWG, inclusive. The conductors shall be Types TW, RHW, or other conductors approved for the purpose. In addition to the insulated conductors, the cable may have an approved size of uninsulated or bare conductor for grounding purposes only. The over-all covering shall be flame-retardant, moisture-resistant, fungus-resistant and corrosive-resistant, and suitable for direct burial in the earth.

(b) Marking. In addition to the provisions of Section 310-2, the cable shall have a distinctive marking on the exterior for its entire length specifying cable type.

339-2. Other Articles. In addition to the provisions of this Article, installations of underground feeder and branch circuit cable (Type UF) shall comply with other applicable provisions of this Code. See especially Article 300, and Section 310-2(b).

339-3. Use.

(a) Underground feeder and branch circuit cable may be used underground, including direct burial in the earth, as feeder or branch circuit cable when provided with overcurrent protection of the rated ampacity as required in Section 339-4.

(b) Where single conductor cables are installed, all cables of the feeder circuit, sub-feeder circuit, or branch circuit, including the neutral conductor, if any, shall be run together in the same trench or raceway.

(c) A minimum depth of 18 inches shall be maintained for conductors and cables buried directly in the earth, when supplementary protection from physical injury such as a covering board, concrete pad, raceway, etc., is not provided.

(d) Type UF cable may be used for interior wiring in wet, dry, or corrosive locations under the recognized wiring methods of this Code, and when installed as nonmetallic sheathed cable it shall conform with the installation provisions of Article 336 and shall be of the multiple conductor type, except where recognized under the provisions of Section 422-44.

(e) This type of cable shall not be used: (1) as service-entrance cables; (2) in commercial garages; (3) in theatres except as provided in Section 520-4; (4) in motion picture studios; (5) in storage battery rooms; (6) in hoistways; (7) in any hazardous location; (8) embedded in poured cement, concrete or aggregate, except where recognized in Article 422; (9) when exposed to direct rays of the sun, unless approved for the purpose.

339-4. Overcurrent Protection. Overcurrent protection shall be provided in accordance with provisions of Section 240-5.

339-5. Rated Ampacity. The ampacities of conductors in Type UF cable shall be according to Tables 310-12 and 310-14.

ARTICLE 342 — NONMETALLIC EXTENSIONS

342-1. Description. Nonmetallic extensions are an assembly of two insulated conductors within a nonmetallic jacket or an extruded thermoplastic covering. The classification includes both surface extensions, intended for mounting directly on the surface of walls or ceilings, and aerial cable, containing a supporting messenger cable as an integral part of the cable assembly.

342-2. Other Articles. In addition to the provisions of this Article, nonmetallic extensions shall conform to other applicable provisions of this Code.

342-3. Use Permitted. Nonmetallic extensions may be used only where all of the following conditions are met:

(a) The extension is from an existing outlet on a 15 or 20 ampere branch circuit in conformity with the requirements of Article 210.

(b) The extension is run exposed and in a dry location.

(c) For nonmetallic surface extensions, the building is occupied for residential or office purposes.

(d) For aerial cable, the building is occupied for industrial purposes, and the nature of the occupancy requires a highly flexible means for connecting equipment.

342-4. Use Prohibited. Nonmetallic extensions shall not be installed:

(a) As aerial cable to substitute for one of the general wiring methods specified by this Code.

(b) In unfinished basements, attics, or roof spaces.

(c) Where voltage between conductors exceeds 150 volts for nonmetallic surface extension and 300 volts for aerial cable.

(d) Where subject to corrosive vapors.

(e) Where run through a floor or partition, or outside the room in which it originates.

342-5. Splices and Taps. Extensions shall consist of a continuous unbroken length of the assembly, without splices, and without exposed conductors between fittings. Taps may be made where approved fittings completely covering the tap connections are used. Aerial cable and its tap connectors shall be provided with an approved means for polarization. Receptacle type tap connectors shall be of the locking type.

342-6. Fittings. Each run shall terminate in a fitting which covers the end of the assembly. All fittings and devices shall be of a type approved for the purpose.

342-7. Installation. Nonmetallic extensions shall be installed in conformity with the following requirements:

(a) Nonmetallic Surface Extensions.

(1) One or more extensions may be run in any direction from an existing outlet, but not on the floor or within 2 inches from the floor.

(2) Nonmetallic surface extensions shall be secured in place by approved means at intervals not exceeding 8 inches, except that where connection to the supplying outlet is made by means of an attachment plug the first fastening may be placed 12 inches or less from the plug. There shall be at least one fastening between each two adjacent outlets supplied. An extension shall be attached only to woodwork or plaster finish, and shall not be in contact with any metal work or other conductive material except with metal plates on receptacles.

(3) A bend which reduces the normal spacing between the conductors shall be covered with a cap to protect the assembly from physical damage.

(b) Aerial Cable.

(1) Aerial cable shall be supported by its messenger cable, securely attached at each end with approved clamps and turnbuckles. Intermediate supports shall be provided at not more than 20 foot intervals. Cable tension shall be adjusted to eliminate excessive sag. The cable shall have a clearance of not less than 2 inches from steel structural members or other conductive material.

(2) Aerial cable shall have a clearance of not less than 10 feet above floor areas accessible to pedestrian traffic, and not less than 14 feet above floor areas accessible to vehicular traffic.

(3) Cable suspended over work benches, not accessible to pedestrian traffic, shall have a clearance of not less than 8 feet above the floor.

(4) Aerial cable may serve to support lighting fixtures when the total load on the supporting messenger cable does not exceed that for which the assembly is intended.

(5) The supporting messenger cable, when conforming to the applicable provisions of Article 250 and when properly identified as a grounding conductor, may be used for the grounding of equipment. The messenger cable shall not be used as a branch circuit conductor.

ARTICLE 344 — UNDERPLASTER EXTENSIONS

344-1. Use. An underplaster extension installed as permitted by this Article, may be used only for extending an existing branch circuit in a building of fire-resistive construction.

344-2. Materials. Such extensions shall be run in rigid or flexible conduit, Type AC metal-clad cable, electrical metallic tubing, Type MI cable or metal raceways approved for the purpose. Standard sizes of conduit, cable, tubing and raceways shall be used except that for a single conductor only conduit or tubing having not less than 5/16 inch inside diameter, single-conductor Type AC metal-clad cable or single conductor Type MI cable may be used.

344-3. Box and Fittings. See Article 370.

344-4. Installation. An underplaster extension shall be laid on the face of masonry or other material and buried in the plaster finish of ceilings or walls. The methods of installation of the raceway or cable for such extension shall be as specified elsewhere in this Code for the particular type of material used.

344-5. Extension to Another Floor. No such extension shall extend beyond the floor on which it originates unless installed in a standard size of rigid metal conduit, electrical metallic tubing, Type AC metal-clad cable, or MI cable.

ARTICLE 346 — RIGID METAL CONDUIT

Note: Where conduit is threaded in the field, it is assumed that a standard conduit cutting die providing ¾ inch taper per foot will be employed.

346-1. Use. Rigid metal conduit may be used under all atmospheric conditions and occupancies, except that ferrous raceways and fittings protected from corrosion solely by enamel may be used only indoors and in occupancies not subject to severe corrosive influences. Where practicable dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

> Unless made of a material judged suitable for the condition, or unless corrosion protection approved for the condition is provided, aluminum, ferrous or non-ferrous metallic conduit, elbows, couplings, and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences. Where dissimilar metals are used in conductors and couplings, the effects of galvanic action shall be eliminated by use of an approved material.

See Section 300-5 for limitation in the use of ferrous raceways and fittings protected from corrosion solely by enamel.

346-2. Other Articles. Installations of rigid metal conduit shall comply with the provisions of the applicable Sections of Article 300.

A. Installation

346-3. Cinder Fill. Conduit, unless of corrosion-resistant material suitable for the purpose shall not be used in or under cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches thick or unless the conduit is at least 18 inches under the fill.

346-4. Wet Locations. All supports, bolts, straps, screws, etc., shall be of corrosion-resistant materials or protected against corrosion by approved corrosion-resistant materials.

See Section 300-5.

346-5. Minimum Size. No conduit smaller than ½ inch, electrical trade size, shall be used, except as provided for underplaster extensions in Article 344, and for enclosing the leads of motors as permitted in Section 430-145(b).

346-6. Number of Conductors in Conduit. The number of conductors permitted in a single conduit shall be as follows:

(a) New Work:

(1) Where conductors are all of the same size, use Tables 1 and 2 of Chapter 9.

(2) Where conductors are of various sizes to be used in combination, use Tables 3 and 4 of Chapter 9 and the dimensions of Column 3 of Table 5 of Chapter 9. Where bare conductors are permitted by other Sections of this Code, the dimensions for bare conductors in Table 8 of Chapter 9 may be used.

(b) Rewiring Existing Conduits:

(1) For rewiring existing conduits where conductors are all of the same size use Tables 1, 1A, and 1B of Chapter 9.

(2) Where conductors are of various sizes to be used in combination use Tables 3 and 4 of Chapter 9, and the dimensions of Column 3, 5, or 7 of Table 5, Chapter 9.

Where bare conductors are permitted by other Sections of this Code, the dimensions for bare conductors in Table 8 of Chapter 9 may be used.

346-7. Reaming. All cut ends of conduits shall be reamed to remove rough edges.

346-8. Bushings. Where a conduit enters a box or other fitting, a bushing shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to afford equivalent protection. See Section 373-6(b) for the protection of conductors at bushings.

346-9. Couplings.

(a) Threadless couplings and connectors used with conduit shall be made tight. Where installed in wet places or where buried in masonry, concrete, or fill, they shall be of a type to prevent water from entering the conduit.

(b) Running threads shall not be used on conduit for connection at couplings.

346-10. Bends — How Made. Bends of rigid conduit shall be so made that the conduit will not be injured, and that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in Table 346-10.

Table 346-10

Radius of Conduit Bends

Size of Conduit	Conductors Without Lead Sheath	Conductors With Lead Sheath
½ in.	4 in.	6 in.
¾ in.	5 in.	8 in.
1 in.	6 in.	11 in.
1¼ in.	8 in.	14 in.
1½ in.	10 in.	16 in.
2 in.	12 in.	21 in.
2½ in.	15 in.	25 in.
3 in.	18 in.	31 in.
3½ in.	21 in.	36 in.
4 in.	24 in.	40 in.
5 in.	30 in.	50 in.
6 in.	36 in.	61 in.

346-11. Bends — Number in One Run. A run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall not contain more than the equivalent of 4 quarter bends (360 degrees, total), including those bends located immediately at the outlet or fitting.

346-12. Supports. Rigid metal conduit shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place. Conduit shall be firmly fastened within 3 feet of each outlet box, junction box, cabinet, or fitting. Conduit shall be supported at least every ten feet except that straight runs of rigid conduit made up with approved threaded couplings may be secured in accordance with Table 346-12, provided such fastening prevents transmission of stresses to terminus when conduit is deflected between supports.

Table 346-12

Conduit Size (Inches)	Maximum distance between rigid metal conduit supports (Feet)
½	10
¾	10
1	12
1¼	14
1½	14
2	16
2½	16
3	20

346-13. Boxes and Fittings. See Article 370.

B. Construction Specifications

346-14. General. Rigid metal conduit shall conform to the following:

(a) Rigid conduit as shipped shall be in standard lengths of 10 feet including coupling, one coupling to be furnished with each length. Each length shall be reamed and threaded on each end. For specific applications or uses, lengths shorter or longer than 10 feet, with or without couplings, may be shipped.

(b) Steel conduit shall have an interior coating of a character and appearance so as to readily distinguish it from ordinary pipe commonly used for other than electrical purposes.

(c) Nonferrous conduit of corrosion-resistant material shall have suitable markings.

(d) Each length shall be clearly and durably identified in every 10 feet with the manufacturer's name or trademark and type of material.

ARTICLE 347 — RIGID NONMETALLIC CONDUIT

347-1. Description. The provisions of this Article shall apply to a type of conduit and fittings of suitable nonmetallic material which is resistant to moisture and chemical atmospheres. For use above ground, it shall also be flame retardant, resistant to impact and crushing, shall resist distortion due to heat under conditions likely to be encountered in service and shall be resistant to low temperature and sunlight effects. For use underground, the material shall be acceptably resistant to moisture and corrosive agents and shall be of sufficient strength to withstand abuse, such as by impact and crushing, in handling and during installation. Where intended for direct burial, without encasement in concrete, the material shall also be capable of withstanding continued loading which is likely to be encountered after installation.

Materials which have been recognized as having suitable physical characteristics when properly formed and treated include fiber, asbestos cement, soapstone, rigid polyvinyl chloride and high density polyethylene for underground use and rigid polyvinyl chloride for use above ground.

347-2. Use Permitted. Rigid nonmetallic conduit and fittings approved for the purpose may be used under the following conditions and where the potential is 600 volts or less except as noted in Section 347-3.

(a) Underground if encased in not less than two inches of concrete.

(b) Direct earth burial if of a type approved for the purpose and if buried not less than 24 inches below the surface.

(c) In concrete walls, floors and ceilings.

(d) In locations subject to severe corrosive influences as set forth in Section 300-5 and where subject to chemicals for which the materials are specifically approved.

(e) Cinder fill.

(f) Wet Locations. In portions of dairies, laundries, canneries or other wet locations and in locations where walls are frequently washed, the entire conduit system including boxes and fittings used therewith shall be so installed and equipped as to prevent water from entering the conduit. All supports, bolts, straps, screws, etc., shall be of corrosion-resistant materials or protected against corrosion by approved corrosion-resistant materials.

(g) In dry and damp locations not prohibited by Section 347-3.

347-3. Use Prohibited. Rigid nonmetallic conduit shall not be used:

(a) Less than 8 feet above ground outdoors unless protected against physical damage.

(b) In hazardous locations except as covered in Section 514-8.

(c) In the concealed spaces of combustible construction.

(d) For the support of fixtures or other equipment.

(e) Where subject to physical damage.

(f) Where subject to ambient temperatures exceeding those for which the conduit had been tested.

(g) For conductors whose insulation temperature limitations would exceed those for which the conduit had been tested.

(h) For potentials exceeding 600 volts unless encased in not less than 2 inches of concrete.

(i) In the sunlight unless approved for the purpose.

347-4. Other Articles. Installation of rigid nonmetallic conduit shall comply with provisions of the applicable sections of Article 300.

A. Installations

347-5. Trimming. All cut ends shall be trimmed inside and outside to remove rough edges.

347-6. Joints. All joints between lengths of conduit, and between conduit and couplings, fittings and boxes shall be made by a method specifically approved for the purpose.

347-8. Supports. Rigid nonmetallic conduit shall be adequately supported as required in Table 347-8. In addition, there shall be a support within 4 feet of each box, cabinet or other conduit termination.

Table 347-8
Support of Rigid Nonmetallic Conduit

Conduit Size Inches	Maximum Spacing between Supports Feet
½	4
¾	4
1	5
1¼	5
1½	5
2	5
2½	6
3	6
3½	7
4	7
5	7
6	8

347-9. Expansion Joints. Expansion joints for rigid nonmetallic conduit shall be provided where required to compensate for thermal expansion and contraction.

347-10. Minimum Size. No conduit smaller than ½ inch electrical trade size shall be used.

347-11. Number of Conductors. The number of conductors permitted in a single conduit shall be as follows:

(a) New Work:

(1) Where conductors are all of the same size, Tables 1 and 2 of Chapter 9.

(2) Where conductors are of various sizes to be used in combination, use Tables 3 and 4 of Chapter 9 and the dimensions of conductors in Column 3 of Table 5 of Chapter 9. Where bare conductors are permitted by other Sections of this Code, the dimensions for bare conductors in Table 8 of Chapter 9 may be used.

(3) When equipment grounding is required by Article 250, a separate grounding conductor shall be installed in the conduit.

(b) Rewiring: Same as specified for new work.

347-12. Bushings. Where a conduit enters a box or other fitting, a bushing or adapter shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to provide equivalent protection. See Section 373-6(b) for the protection of conductors at bushings.

347-13. Bends, How Made. Bends of rigid nonmetallic conduit shall be so made that the conduit will not be injured and that the internal diameter of the conduit will not be effectively reduced. Field bends shall be made only with bending equipment specifically approved for the purpose, and the radius of the curve of the inner edge of such bends shall be not less than shown in Table 346-10.

347-14. Bends, Number in One Run. A run of conduit between outlet and outlet, between fitting and fitting or between outlet and fitting shall not contain more than the equivalent of four quarter bends (360°) total including those bends located immediately at the outlet or fitting.

347-15. Boxes and Fittings. See Article 370.

B. Construction Specifications

347-16. General. Rigid nonmetallic conduit shall conform to the following:

(a) Rigid nonmetallic polyvinyl chloride conduit as shipped shall be in standard lengths of 10 feet including couplings, one coupling to be furnished with each length. For specific applications or uses, lengths shorter or longer than 10 feet with or without couplings may be shipped.

(b) High density polyethylene conduit as shipped shall be in standard lengths of 10 feet. One threaded coupling shall be furnished with each threaded length of high density polyethylene conduit. For specific applications or uses, lengths shorter or longer than 10 feet with or without couplings may be shipped.

(c) Each length of nonmetallic conduit shall be clearly and durably marked at least every ten feet with the manufacturer's name, trade name, or trademark, nominal trade size, and type of material.

For conduit recognized for use above ground these markings shall be permanent. For conduit limited to underground use only, these markings shall be sufficiently durable to remain legible until the material is installed.

ARTICLE 348 — ELECTRICAL METALLIC TUBING

348-1. Use. Electrical metallic tubing may be used for both exposed and concealed work. Electrical metallic tubing protected from corrosion solely by enamel shall not be used. Electrical metallic tubing shall not be used (1) where during installation or afterward, it will be subject to severe physical damage; (2) in concrete, cinder concrete or fill where subject to permanent moisture.

Unless made of a material judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or nonferrous electrical metallic tubing, elbows, couplings and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

See Section 300-5 for limitation in the use of ferrous raceways and fittings protected from corrosion solely by enamel.

348-2. Other Articles. Installations of electrical metallic tubing shall comply with the provisions of the applicable sections of Article 300.

A. Installation

348-4. Wet Locations. All supports, bolts, straps, screws, etc. shall be of corrosion-resistant materials or protected against corrosion by approved corrosion-resistant materials. See Section 300-5.

348-5. Minimum and Maximum Sizes. No tubing smaller than ½ inch, electrical trade size, shall be used except as provided for underplaster extensions in Article 344 and for enclosing the leads of motors as permitted in Section 430-145(b). The maximum size of tubing shall be the 4-inch electrical trade size.

348-6. Number of Conductors in Tubing. One tubing shall not contain more conductors than as provided in Section 346-6.

348-7. Threads. Tubing shall not be coupled together nor connected to boxes, fittings, or cabinets by means of threads in the wall of the tubing, except by fittings approved for the purpose. Threads shall not be of the standard pipe thread dimensions.

348-8. Couplings and Connectors. Threadless couplings and connectors used with tubing shall be made up tight. Where installed in wet locations, they shall be of the raintight type.

348-9. Bends — How Made. Bends in the tubing shall be so made that the tubing will not be injured and that the internal diameter of the tubing will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in Table 346-10.

348-10. Bends — Number in One Run. A run of electrical metallic tubing between outlet and outlet, between fitting and fitting, or between outlet and fitting, shall not contain more than the equivalent of four quarter bends (360 degrees, total), including those bends located immediately at the outlet or fitting.

348-11. Reaming. All cut ends of electrical metallic tubing shall be reamed to remove rough edges.

348-12. Supports. Electrical metallic tubing shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place at least every 10 feet and within 3 feet of each outlet box, junction box, cabinet, or fitting.

348-13. Boxes and Fittings. See Article 370.

B. Construction Specifications

348-14. General. Electrical metallic tubing shall conform to the following:

(a) Cross Section. The tubing, and elbows and bends for use with the tubing, shall have a circular cross section.

(b) Finish. Tubing shall have such a finish or treatment of outer surfaces as will provide an approved durable means of readily distinguishing it, after installation, from rigid conduit.

(c) Connectors. Where the tubing is coupled together by threads, the connector shall be so designed as to prevent bending of the tubing at any part of the thread.

ARTICLE 350 — FLEXIBLE METAL CONDUIT

350-1. Other Articles. Installations of flexible metal conduit shall comply with the appropriate (or applicable) provisions of Articles 300, 334, and 346.

350-2. Use. Flexible metal conduit shall not be used (1) in wet locations, unless conductors are of the lead-covered type or of other type specially approved for the conditions; (2) in hoistways, except as provided in Section 620-21; (3) in storage-battery rooms; (4) in any hazardous location except as permitted in Sections 501-4(b), 502-4 and 503-3; nor (5) where rubber-covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber.

350-3. Minimum Size. No flexible metal conduit less than one-half inch electrical trade size shall be used except (1) as permitted for underplaster extensions by Section 344-2; (2) as permitted for motors by Section 430-145 (b); and (3) for connection not over 48 inches in length, or longer on approved assemblies, to equipment where the use of one-half inch or larger size flexible metal conduit is not practicable, in which case flexible metal conduit of three-eighth inch electrical trade size may be used.

Table 350-3

Maximum Number of Conductors in ⅜″ Flexible Metal Conduit

Size AWG	Types RF-32, R, RH	Type RW-RHW	Types TF, T, TW, RU, RUF, RUW
18	4	—	8
16	3	—	6
14	3	2	5
12	2	2	4
10	—	—	3

350-4. Supports. When flexible metal conduit is installed it shall be secured by approved means at intervals not exceeding 4½ feet and within 12 inches on each side of every outlet box or fitting, except where flexible conduit is fished, and except for lengths of not over 36 inches at terminals where flexibility is necessary.

ARTICLE 351 — LIQUIDTIGHT FLEXIBLE METAL CONDUIT

351-1. Purpose. Liquidtight flexible metal conduit is not intended as a general purpose raceway material. The provisions of this Article shall apply to a type of flexible conduit having an outer liquidtight jacket and employed with suitable terminal fittings approved for the purpose.

351-2. Use. The use of this wiring material shall be restricted as follows:

(a) For the connection of motors or portable equipment where flexibility of connection is required.

(b) Liquidtight flexible metal conduit shall not be used under the following conditions: (1) where subject to physical damage; (2) where in contact with rapidly moving parts; (3) under conditions such that its temperature, with or without enclosed conductors carrying current, is above 60°C (140°F); (4) in any hazardous location, except as described in Section 501-4(b) and Sections 502-4 and 503-3, unless it is specially approved for such use.

351-3. Maximum Size. The maximum size of liquidtight flexible metal conduit shall not exceed 3 inch electrical trade size.

351-4. Conductor Size. The maximum size of conductor installed in liquidtight flexible metal conduit shall not exceed the following values:

Table 351-4

Trade Size of Conduit	Size of Conductor
⅜ inch	16 Awg
½ inch	12 Awg
¾ inch	8 Awg
1 inch	6 Awg
1¼ inch	2 Awg
1½ inch	1 Awg
2 inch	00 Awg
2½ inch	0000 Awg
3 inch	350 MCM

Liquidtight flexible metallic conduit in sizes 1½ inch and larger shall be bonded in accordance with Section 250-79 unless specifically approved for use without a separate bond.

ARTICLE 352 — SURFACE METAL RACEWAYS

352-1. Use. Surface metal raceways may be installed in dry locations. They shall not be used (1) where concealed, except that metal raceways approved for the purpose may be used for underplaster extensions; (2) where subject to severe physical damage unless approved for the purpose; (3) where the voltage is 300 volts or more between conductors unless the metal has a thickness of not less than .040 inch; (4) where subject to corrosive vapors; (5) in hoistways; nor (6) in any hazardous location.

352-2. Other Articles. Installations of surface metal raceways shall comply with the applicable provisions of Article 300.

A. Installation

352-3. Size of Conductors. No conductor larger than that for which the raceway is designed shall be installed in surface metal raceway.

352-4. Number of Conductors in Raceways. The number of conductors installed in any raceway shall be no greater than the number for which the raceway is designed.

352-5. Extension Through Walls and Floors. Except in multioutlet assemblies, raceways may be extended through dry walls, dry partitions and dry floors, if in unbroken lengths where passing through.

352-6. Combination Raceways. Where combination metal raceways are used both for signal and for lighting and power circuits, the different systems shall be run in separate compartments, identified by sharply contrasting colors of the interior finish, and the same relative position of compartments shall be maintained throughout the premises.

B. Construction Specifications

352-7. General. Surface metal raceways shall be of such construction as will distinguish them from other raceways. Surface metal raceways and their elbows, couplings, and similar fittings shall be so designed that the sections can be electrically and mechanically coupled together, while protecting the wires from abrasion. Holes for screws or bolts inside the raceway shall be so designed that when screws or bolts are in place their heads will be flush with the metal surface.

ARTICLE 353 — MULTIOUTLET ASSEMBLY

353-1. Other Articles. Installations of multioutlet assembly shall comply with applicable provisions of Article 300. See definition in Article 100.

353-2. Use. Multioutlet assembly may be installed in dry locations. It shall not be installed (1) where concealed, except that the back and sides of metal multioutlet assembly may be surrounded by the building finish and nonmetallic multioutlet assembly may be recessed in the baseboard; (2) where subject to severe physical damage unless approved for the purpose; (3) where the voltage is 300 volts or more between conductors unless assembly is of metal having a thickness of not less than .040 inch; (4) where subject to corrosive vapors; (5) in hoistways; nor (6) in any hazardous locations.

353-3. Metal Multioutlet Assembly Through Dry Partitions. Metal multioutlet assembly may be extended through (not run within) dry partitions, providing arrangements are made for removing the cap or cover on all exposed portions and no outlet is located within the partitions.

ARTICLE 354 — UNDERFLOOR RACEWAYS

354-1. Other Articles. Installations of underfloor raceways shall comply with the applicable provisions of Article 300.

354-2. Use. Underfloor raceways may be installed beneath the surface of concrete or other flooring material, or in office occupancies, where laid flush with the concrete floor and covered with linoleum or equivalent floor covering. Underfloor raceways shall not be installed (1) where subject to corrosive vapors nor (2) in any hazardous location. Unless made of a material judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or nonferrous metallic underfloor raceways, junction boxes, and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

354-3. Covering. Raceway coverings shall conform to the following:

(a) Raceways Not Over 4 Inches Wide. Half-round raceways not over 4 inches in width, and, except as permitted in (c) flat-top raceways not over 4 inches in width, shall have not less than ¾ inch of concrete or wood above the raceway.

(b) Raceways 4 Inches Wide but Not Over 8 Inches Wide. Flat top raceways 4 inches wide with a minimum of 1 inch spacing between raceways shall be covered with concrete to a depth of not less than 1 inch. Raceways spaced less than 1 inch apart shall be covered with concrete to a depth of 1½ inches.

(c) Raceways Flush With Concrete. Approved flush raceways with removable covers may be laid flush with the floor surface. Such approved raceways shall be so designed that the cover plates will provide adequate mechanical protection and rigidity equivalent to junction box covers.

354-4. Size of Conductors. No conductor larger than that for which the raceway is approved shall be installed in underfloor raceways and the largest size conductor allowed shall be 500,000 cm.

354-5. Number of Conductors in Raceway. The combined cross-sectional area of all conductors shall not exceed 40 per cent of the interior area of the raceway; except that where the raceway contains only armored cable or nonmetallic sheathed cable, these requirements shall not apply.

354-6. Splices and Taps. Splices or taps shall be made only in junction boxes.

See Tentative Interim Amendment No. 127 at back of book.

354-7. Discontinued Outlets. When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway. No splices or reinsulated conductors such as would be the case with abandoned outlets on loop wiring, shall be allowed in raceways.

354-8. Laid in Straight Lines. Underfloor raceways shall be laid so that a straight line from the center of one junction box to the center of the next junction box will coincide with the center line of the raceway system. Raceways shall be firmly held in place to prevent disturbing this alignment during construction.

354-9. Markers at Ends. At every end of line of raceway, and at other locations where the location of the raceway is not apparent, a suitable number of markers shall be installed extending through the floor for future location of inserts and for system identification.

354-10. Dead Ends. Dead ends of raceways shall be closed.

354-11. Low Points. Where practicable, raceways and their fittings shall be so arranged as to avoid low points that may form traps for water.

354-12. Fittings at Angles. Where raceways are run at other than right angles, special fittings shall be provided.

354-13. Junction Boxes. Junction boxes shall be leveled to the floor grade and sealed against the entrance of water. Junction boxes used with metal raceways shall be metal and shall be electrically continuous with the raceways.

354-14. Inserts. Inserts shall be leveled to the floor grade and sealed against the entrance of water. Inserts used with metal raceways shall be metal and shall be electrically continuous with the raceway. Inserts set in or on fiber raceways before the floor is laid shall be mechanically secured to the raceway. Inserts set in fiber raceways after the floor is laid shall be screwed into the raceway. In cutting through the raceway wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are so designed as to prevent the tool from entering the raceway and injuring conductors that may be in place.

354-15. Connections to Cabinets and Wall Outlets. Connections between raceways and distribution centers and wall outlets shall be made by means of rigid or flexible metal conduit or by means of fittings approved for the purpose.

ARTICLE 356 — CELLULAR METAL FLOOR RACEWAYS

356-1. Definitions. For the purposes of this Article, a "cellular metal floor raceway" shall be defined as the hollow spaces of cellular metal floors, together with suitable fittings, which may be approved as enclosures for electrical conductors; a "cell" shall be defined as a single, enclosed tubular space in a cellular metal floor member, the axis of the cell being parallel to the axis of the metal floor member; a "header" shall be defined as a transverse raceway for electrical conductors, providing access to predetermined cells of a cellular metal floor, thereby permitting the installation of electrical conductors from a distribution center to the cells.

356-2. Use. Conductors shall not be installed in cellular metal floor raceways (1) where subject to corrosive vapor; (2) in any hazardous location; nor (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above. No electric conductors shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or other service than electrical.

356-3. Other Articles. Installations of conductors in the raceways of cellular metal floor shall comply with the applicable provisions of Article 300.

A. Installation

356-4. Size of Conductors. No conductor larger than No. 0 shall be installed, except by special permission.

356-5. Number of Conductors in Raceway. The total cross-sectional area of all conductors in a header or in an individual cell shall not exceed 40% of the cross-sectional area of the header or cell in which they are located; except that where the raceway contains only Type AC metal-clad cable or nonmetallic sheathed cable, these requirements shall not apply.

356-6. Splices and Taps. Splices and taps shall be made only in header access units or junction boxes.

356-7. Discontinued Outlets. When an outlet is discontinued, the conductors supplying the outlet shall be removed from the raceway.

356-8. Markers. A suitable number of markers shall be installed extending through the floor for the future locating of cells and for system identification.

356-9. Junction Boxes. Junction boxes shall be levelled to the floor grade and sealed against the entrance of water. Junction boxes used with these raceways shall be of metal and shall be electrically continuous with the raceway.

356-10. Inserts. Inserts shall be levelled to the floor grade and sealed against the entrance of water. Inserts shall be of metal and shall be electrically continuous with the raceway. In cutting through the cell wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are designed to prevent the tool from entering the cell and injuring the conductors.

356-11. Connection to Cabinets and Extensions from Cells. Connections to cabinets and extensions from cells to outlets shall be made by means of rigid or flexible conduit or by means of fittings approved for the purpose.

B. Construction Specifications

356-12. General. Cellular metal floor raceways shall be so constructed that adequate electrical and mechanical continuity of the complete system will be secured. They shall provide a complete enclosure for the conductors. The interior surfaces shall be free from burrs and sharp edges, and surfaces over which conductors are drawn shall be smooth. Suitable bushings or fittings having smooth rounded edges shall be provided where conductors pass.

ARTICLE 357 — STRUCTURAL RACEWAYS

357-1. Definitions. Structural raceways are formed steel members approved for the installation of electrical wires or cables within them.

(a) Vertical members used for studs or columns shall be tubes or channels.

(b) Horizontal headers used as beams or top plates shall be provided with suitable covers, end closers, and fittings.

357-2. Use. Structural raceways used to enclose electrical conductors shall be used only in single-family dwellings.

357-3. Other Articles. Installation of conductors in structural raceways shall comply with the applicable provisions of Article 300.

A. Installation

357-4. Openings in Vertical Members. Vertical members may have openings provided in them for the purpose of installing wiring devices. Vertical members may be concealed. Openings in vertical members shall provide access to wiring. The size of such openings shall comply with the provisions of Section 300-15 and Article 370. Wiring devices may be installed in openings in vertical members without the use of individual boxes, provided that the back and sides of each device are surrounded by terminal barriers.

357-5. Horizontal Headers. Horizontal headers shall be securely fastened to vertical members.

357-6. Number of Conductors in Raceway. Structural raceways shall not contain more than 20 current-carrying conductors at any cross-section, and the total cross-sectional areas of all contained conductors shall not exceed 20 per cent of the interior cross-section.

357-7. Splices and Taps. Splices and taps shall be made only in horizontal headers, or junction boxes. The conductors including splices and taps shall not fill the structural raceway to more than 75 per cent of its area at that point. All splices and taps shall be made and insulated by approved methods.

357-8. Size of Conductors. No conductor larger than Number 6 AWG shall be installed in vertical or horizontal members.

357-9. Accessibility. The covers of the horizontal members shall be accessible after installation and shall not be obstructed by the wall finish.

357-10. Fittings. Fittings shall be designed and installed to prevent physical damage to electrical conductors. Fittings shall be free from burrs and sharp edges.

357-11. Extensions from vertical structural members. Extensions from vertical structural members shall be made with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway or metal-clad cable.

357-12. Dead Ends. Dead ends of structural raceways shall be closed.

357-13. Installation of Electrical Devices. The installation of switches, receptacles, and outlets shall be in accordance with the requirements of Articles 380 and 410, except as otherwise permitted in this Article.

357-14. Grounding. All elements of structural raceway systems shall be bonded and effectively grounded.

B. Construction Specifications

357-15. Marking. Structural raceways and fittings shall be marked with the manufacturer's name, trademark, or identification symbol.

357-16. General. All metal components shall be properly coated to prevent corrosion. The interior shall be free from sharp edges and burrs. The structural raceway systems shall be constructed to provide electrical and mechanical continuity of the complete system. They shall provide a complete enclosure for the conductors. Enclosures shall be approved for the purpose.

ARTICLE 358 — CELLULAR CONCRETE FLOOR RACEWAYS

358-1. Scope. Approved precast cellular concrete floor raceways shall comply with the applicable requirements of Article 300, and shall also comply with the provisions of Sections 358-2 to 358-11 inclusive. For the purpose of this Article, "precast cellular concrete floor raceways" shall be defined as the hollow spaces in floors constructed of precast cellular concrete slabs, together with suitable metal fittings designed to provide access to the floor cells in an approved manner. A "cell" shall be defined as a single, enclosed tubular space in a floor made of precast cellular concrete slabs, the direction of the cell being parallel to the direction of the floor member. "Header ducts" shall be defined as transverse metal raceways for electrical conductors, furnishing access to predetermined cells of a precast cellular concrete floor, thus providing for the installation of electrical conductors from a distribution center to the floor cells.

358-2. Use. Conductors shall not be installed in precast cellular concrete floor raceways (1) where subject to corrosive vapor; (2) in hazardous locations; nor (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above. No electrical conductors shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or any service other than electrical.

358-3. Header Duct. The header duct shall be installed in a straight line, at right angles to the cells. The header duct shall be mechanically secured to the top of the precast cellular concrete floor. The end joints shall be closed by metallic closure fittings and sealed against the penetration of water. The header duct shall be electrically continuous throughout its entire length and shall be electrically bonded to the enclosure of the distribution center.

358-4. Connection to Cabinets and Other Enclosures. Connection from header duct to cabinets and other enclosures shall be made by means of metallic duct and fittings approved for the purpose.

358-5. Junction Boxes. Junction boxes shall be levelled to the floor grade and sealed against the entrance of water. Junction boxes shall be of metal and shall be mechanically and electrically continuous with the header ducts.

358-6. Markers. Each hidden access point between a header and a cell intended for future use shall be provided with a marker extending through the floor covering. A suitable number of markers shall be installed, extending through the floor covering, to locate the cells and to provide system identification.

358-7. Inserts. Inserts shall be levelled to the floor grade and sealed against the entrance of water. Inserts shall be of metal and shall be fitted with receptacles of the grounded type. A ground conductor shall connect the insert receptacles to a positive ground connection provided on the header duct. In cutting through the cell wall for setting inserts or other purposes (such as providing access openings between header duct and cells) chips and other dirt shall not be allowed to fall into the raceway, and the tool used shall be so designed as to prevent the tool from entering the cell and injuring the conductors.

358-8. Size of Conductors. No conductor larger than No. 0 shall be installed, except by special permission.

358-9. Number of Conductors. The total cross-sectional area of all conductors in a header or in an individual cell shall not exceed 40% of the cross-sectional area of the header or cell in which they are located; except that where the raceway contains only Type AC metal-clad cable or nonmetallic sheathed cable, these requirements shall not apply.

358-10. Splices and Taps. Splices and taps shall be made only in header duct access units or junction boxes.

358-11. Discontinued Outlets. When an outlet is discontinued, the conductors supplying the outlet shall be removed from the header and cell.

ARTICLE 362 — WIREWAYS

362-1. Definition. Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electrical wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

362-2. Use. Wireways may be installed only for exposed work. Wireways intended for outdoor use shall be of approved raintight construction. Wireways shall not be installed: (1) where subject to severe physical damage or corrosive vapor; nor (2) in any hazardous location.

362-3. Other Articles. Installations of wireways shall comply with the applicable provisions of Article 300.

362-4. Size of Conductors. No conductor larger than 500,000 c.m. shall be installed in any wireway.

362-5. Number of Conductors. Wireways shall not contain more than 30 current carrying conductors at any cross section. The sum of the cross-sectional areas of all contained conductors at any cross-section of a wireway shall not exceed 20 per cent of the interior cross-sectional area of the wireway.

Exception No. 1. See Section 620-32.

The correction factors specified in Note 8 to Tables 310-12 through 310-15 are not applicable to the foregoing.

Exception No. 2. Conductors for signal circuits or controller conductors between a motor and its starter and used only for starting duty shall not be considered as current carrying conductors.

362-6. Splices and Taps. Splices and taps, made and insulated by approved methods, may be located within the wireway provided they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than 75 per cent of its area at that point.

362-7. Supports. Wireways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet.

Exception: See Section 620-32.

362-8. Extension Through Walls. Wireways may extend transversely through walls if in unbroken lengths where passing through.

362-9. Dead Ends. Dead ends of wireways shall be closed.

362-10. Extensions From Wireways. Extensions from wireways shall be made with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway or metal-clad cable.

362-11. Marking. Wireways shall be marked so that their manufacturer's name or trademark will be visible after installation.

ARTICLE 364 — BUSWAYS

364-1. Other Articles. Installations of busways shall comply with the applicable provisions of Article 300.

364-2. Use. Busways may be installed only for exposed work. Busways shall not be installed (1) where subject to severe physical damage or corrosive vapors; (2) in hoistways; (3) in any hazardous location; nor (4) outdoors or in wet or damp locations unless specially approved for the purpose.

Busways may be used for service-entrance conductors. See Section 230-44.

Where secondary systems are operated ungrounded, a combination ground detector and potentializer plug shall be used as an auxiliary fitting for busway systems to establish a definite potential difference between the bus-bars and the grounded casing of the busways. This will serve to drain off any static or other charge from the entire busway system including its connected apparatus, supply and branch circuit conductors.

364-3. Support. Busways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet. Where a busway is installed in a vertical position, the supports for the bus-bars shall be designed for vertical installation.

364-4. Extension Through Walls. Busways may extend transversely through dry walls if in unbroken lengths where passing through. Busways may extend vertically through dry floors when totally enclosed (unventilated) where passing through and for a minimum distance of six feet above the floor to provide adequate protection from physical damage.

364-5. Dead Ends. A dead end of a busway shall be closed.

364-7. Branches from Busways. Branches from busways shall be made with busways or with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway, metal-clad cable or with suitable cord assemblies approved for hard usage for portable equipment or for the connection of stationary equipment to facilitate their interchange.

364-8. Overcurrent Protection. Overcurrent protection shall be provided in accordance with Sections 364-9 to 364-13 inclusive.

364-9. Rating of Overcurrent Protection — Feeders and Sub-Feeders. Where the allowable current rating of the busway does not correspond to a standard rating of the overcurrent device, the next higher rating may be used.

364-10. Reduction in Size of Busway. Overcurrent protection may be omitted at points where busways are reduced in size, provided that the smaller busway does not extend more than 50 feet and has a current rating at least equal to one-third the rating or setting of the overcurrent device next back on the line, and provided further that such busway is free from contact with combustible material.

364-11. Branch Circuits. Where a busway is used as a feeder, devices or plug-in connections for tapping off branch-circuits from the busway shall contain the overcurrent devices required for the protection of the branch circuits.

Exception No. 1. For overcurrent protection of taps, see Section 240-15.

Exception No. 2. For fixed or semi-fixed lighting fixtures, the branch circuit overcurrent device may be part of the fixture cord plug on cord-connected fixtures.

Exception No. 3. Where fixtures without cords are plugged directly into the busway, the overcurrent device may be mounted on the fixture.

364-12. Rating of Overcurrent Protection — Branch Circuits. A busway may be used as a branch circuit of any one of the types described in Article 210. When so used, the rating or setting of the overcurrent device protecting the busway shall determine the ampere rating of the branch circuit, and the circuit shall in all respects conform with the requirements of Article 210 that apply to branch circuits of that rating.

364-13. Length of Busways Used as Branch Circuits. Busways which are used as branch circuits and which are so designed that loads can be connected at any point shall be limited to such lengths as will provide that in normal use the circuits will not be overloaded.

In general, the length of such run in feet should not exceed three times the ampere rating of the branch circuit.

364-14. Marking. Busways shall be marked with the voltage and current rating for which they are designed, and with the manufacturer's name or trademark in such manner as to be visible after installation.

ARTICLE 370 — OUTLET, SWITCH AND JUNCTION BOXES, AND FITTINGS

A. Scope and General

370-1. Scope. The provisions of this Article shall apply to the installation of outlet, switch and junction boxes, and fittings as required by Section 300-15. Installations in hazardous locations shall conform to Articles 500 to 517 inclusive.

370-2. Round Boxes. Round boxes shall not be used where conduits or connectors requiring the use of locknuts or bushings are to be connected to the side of the box.

370-3. Nonmetallic Boxes. Nonmetallic boxes approved for the purpose may be used only with open wiring on insulators, concealed knob-and-tube work, nonmetallic sheathed cable, and with approved nonmetallic conduit.

370-4. Metallic Boxes. Where used with knob-and-tube work or nonmetallic sheathed cable, and mounted on metal or metal lath ceilings or walls, such boxes shall be insulated from their supports and from the metal or metal lath, or shall be grounded.

B. Installation

370-5 Damp or Wet Locations. In damp or wet locations, boxes and fittings shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the box or fitting. Boxes and fittings installed in wet locations shall be weatherproof. For boxes in floors, see Section 410-53.

Approved boxes of nonconductive material shall be used with nonmetallic sheathed cable or approved nonmetallic conduit when such cable or conduit is used in locations where there is likely to be occasional moisture present such as in dairy barns.

370-6. Number of Conductors in a Box. Boxes shall be of sufficient size to provide free space for all conductors enclosed in the box.

The limitations in Section 370-6(a and b) shall not apply to terminal housings supplied with motors, nor to types of boxes or fittings without knockout and having hubs or recessed parts for terminal bushings and locknuts.

Section 370-6(a and b) does not apply to conductors used for rewiring existing raceways as referred to in Table 3, Chapter 9.

(a) The maximum number of conductors, not counting fixture wires, permitted in outlet and junction boxes shall be as in Tables 370-6(a-1 and -2) with the exceptions noted.

Tables 370-6(a-1 and -2) apply where no fittings or devices, such as fixture studs, cable clamps, hickeys, switches or receptacles are contained in the box. Where one or more fixture studs, cable clamps, or hickeys are contained in the box, the number of conductors shall be one less than shown in the Tables, with a further deduction of one conductor for one or several flush devices mounted on the same strap. A conductor running through the box is counted as one conductor and each conductor originating outside the box and terminating inside the box is counted as one conductor. Conductors of which no part leaves the box are not to be counted in the above computation. If single flush boxes are ganged, and each section is occupied by a flush device or combination of flush devices on the same strap, the limitations will apply to each section individually.

Table 370-6(a-1)—Deep Boxes

Box Dimensions, Inches Trade Size	Maximum Number of Conductors				
	No. 14	No. 12	No. 10	No. 8	No. 6*
1½ x 3¼ octagonal. .	5	5	4	0	0
1½ x 4 octagonal. . . .	8	7	6	5	0
1½ x 4 square.	11	9	7	5	0
1½ x 4 11/16 square.	16	12	10	8	0
2⅛ x 4 11/16 square.	20	16	12	10	6
2 x 1¾ x 2¾.	5	4	4		
2½ x 1¾ x 2¾.	6	6	5		
3 x 1¾ x 2¾.	7	7	6		

Where there is not sufficient space for a deeper box, four No. 14 AWG conductors may enter a box provided with cable clamps and containing one or more devices on a single mounting strap.

* See Section 370-18 where boxes are used as pull and junction boxes.

Table 370-6(a-2)—Shallow Boxes

Box Dimensions, Inches Trade Size	Maximum Number of Conductors		
	No. 14	No. 12	No. 10
3¼.	4	4	3
4.	6	6	4
1¼ x 4 square.	9	7	6
4 11/16.	8	6	6

Any box less than 1½ inch deep is considered to be a shallow box.

(b For combinations not shown in the above Tables, Table 370-6(b) shall apply.

370-7. Conductors Entering Boxes or Fittings. Conductors entering boxes or fittings shall be protected from abrasion, and shall conform to the following:

(a) Openings to Be Closed. Openings through which conductors enter shall be adequately closed.

Size of Conductor	Free Space Within Box for Each Conductor
No. 14	2. cubic inches
No. 12	2.25 cubic inches
No. 10	2.5 cubic inches
No. 8	3. cubic inches
No. 6	5. cubic inches

(b) Metal Boxes and Fittings. Where metal outlet boxes or fittings are installed with open wiring or concealed knob-and-tube work, conductors shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the box or fitting. Where raceway or cable is installed with metal outlet boxes or fittings, the raceway or cable shall be secured to such boxes and fittings.

(c) Nonmetallic Boxes. Where nonmetallic boxes are used with open wiring or concealed knob-and-tube work, the conductors shall enter through individual holes. Where flexible tubing is used to encase the conductor, the tubing shall extend from the last insulating support and may be run into the box or terminate at the wall of the box. If nonmetallic sheathed cable is used, the cable assembly shall enter the box through a knockout opening. Clamping of individual conductors or cables to the box is not required where supported within 8 inches of the box. Where nonmetallic conduit is installed with nonmetallic boxes or fittings, the conduit shall be secured to such boxes and fittings in an approved manner.

(d) Where bond wires are provided, they shall be attached to the yoke of the device by a means suitable for the purpose.

370-8. Unused Openings. Unused openings in boxes and fittings shall be effectively closed to afford protection substantially equivalent to that of the wall of the box or fitting. Metal plugs or plates used with nonmetallic boxes or fittings shall be recessed at least ¼ inch from the outer surface.

370-9. Boxes Enclosing Flush Devices. Boxes used to enclose flush devices shall be of such design that the devices will be completely enclosed on back and sides, and that substantial support for the devices will be provided. Screws for supporting the box shall not be used in attachment of the device contained therein.

370-10. In Wall or Ceiling. In walls or ceilings of concrete, tile or other noncombustible material, boxes and fittings shall be so installed that the front edge of the box or fitting will not set back of the finished surface more than ¼ inch. In walls and ceilings constructed of wood or other combustible material, outlet boxes and fittings shall be flush with the finished surface or project therefrom.

370-11. Repairing Plaster. Except on walls or ceilings of concrete, tile or other noncombustible material, a plaster surface which is broken or incomplete shall be repaired so that there will be no gaps or open spaces at the edge of the box or fitting.

370-12. Exposed Extensions. In making an exposed extension from an existing outlet of concealed wiring, a box, extension ring or blank cover shall be mounted over the original box and electrically and mechanically secured to it. The extension shall then be connected to this box in the manner prescribed for the method of wiring employed in making the extension.

370-13. Supports.

(a) General. Boxes, fittings and cabinets shall be securely fastened in place. Boxes and fittings, not over 100 cubic inches in size, which are attached to firmly secured exposed raceway by threading or other connection designed for the purpose, are considered as so fastened.

(b) Concealed Work. In concealed work, except as prescribed in Section 370-13(c), boxes and fittings, unless securely held in place by concrete, masonry or other building material in which they are embedded, shall be secured to a stud, joist or similar fixed structural unit, or to a metal or wooden support which is secured to such a structural unit. Wooden supports shall be not less than ⅞ inch in thickness. Lath of wood, metal or composition shall not be considered a structural unit. See Sections 410-15 and 410-16 for support of fixtures.

(c) Exposed Work. In exposed work, and in concealed work in existing buildings where conductors or cables are fished and boxes cannot be secured as provided in Section 370-13(b) without disturbing the building finish, the boxes may be mounted directly upon the plaster surface when securely fastened in place.

370-14. Depth of Outlet Boxes for Concealed Work. Outlet boxes for concealed work shall have an internal depth of at least 1½ inches, except that where the installation of such a box will result in injury to the building structure or is impracticable, a box not less than ½ inch internal depth may be installed.

370-15. Covers and Canopies. In completed installations each outlet box shall be provided with a cover unless a fixture canopy is used.

(a) Nonmetallic covers and plates or metallic covers and plates may be used with nonmetallic outlet boxes. When metallic covers or plates are used, they shall comply with the grounding requirements of Section 250-42.

See Section 410-95.

(b) Where a fixture canopy or pan is used, any combustible wall or ceiling finish exposed between the edge of the canopy or pan and the outlet box shall be covered with noncombustible material.

(c) Covers of outlet boxes having holes through which flexible cord pendants pass, shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear. So-called hard-rubber or composition bushings shall not be used.

370-16. Fastened to Gas Pipes. Outlet boxes used where gas outlets are present shall be so fastened to the gas pipes as to be mechanically secure.

370-17. Boxes at Lighting Fixture Outlets. Boxes used at outlets for lighting fixtures shall be designed for the purpose. At every outlet used exclusively for lighting, the box shall be so designed or installed that a lighting fixture may be attached.

370-18. Pull and Junction Boxes. Pull and junction boxes shall conform to the following:

(a) Minimum Size. For raceways of 1 inch trade size and larger, containing conductors of No. 6 or larger, and for cables* containing conductors of No. 6 or larger, the minimum dimensions of a pull or junction box installed in a raceway or cable run shall conform to the following:

(1) Straight Pulls. In straight pulls the length of the box shall be not less than 8 times the trade diameter of the largest raceway.

(2) Angle or U Pulls. Where angle or U pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the largest raceway. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

Exception. The limitations of Section 370-18(a-1 and a-2) are not intended to apply to terminal housings supplied with motors, nor to types of boxes or fittings without knockouts and having hubs or recessed parts for terminal bushings and locknuts.

(b) Conductors in Pull or Junction Boxes. In pull boxes or junction boxes having any dimension over 6 feet, all conductors shall be cabled or racked up in an approved manner.

See Section 373-6(b) for insulation of conductors at bushings.

(c) Covers. All pull boxes, junction boxes and fittings shall be provided with covers approved for the purpose. Where metallic covers are used, they shall comply with the grounding requirements of Section 250-42.

370-19. Junction, Pull and Outlet Boxes Be Accessible. Junction, pull and outlet boxes shall be so installed that the wiring contained in them may be rendered accessible without removing any part of the building, sidewalks or paving.

C. Construction Specifications

370-20. Metallic Outlet, Switch and Junction Boxes and Fittings. Outlet, switch and junction boxes and fittings, when of metal, shall conform to the following.

(a) Corrosion-Resistant. Metallic boxes and fittings, unless of corrosion-resistant metal, shall be well galvanized, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

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* When transposing cable size into raceway size in (1) and (2) above, the minimum trade size raceway required for the number and size of conductors in the cable shall be used.

See Section 300-5 for limitation in the use of boxes and fittings protected from corrosion solely by enamel.

(b) Thickness of Metal. For sheet steel boxes and fittings not over 100 cubic inches in size, the metal shall not be less than No. 14 USS gage (0.0747 inch in thickness). Cast metal boxes shall have a wall thickness of not less than ⅛ inch, except that boxes of malleable iron shall have a wall thickness of not less than 3/32 inch.

(c) Boxes Over 100 Cubic Inches. Boxes of over 100 cubic inches in size shall be composed of metal and shall conform to the requirements for cabinets and cutout boxes, except that the covers may consist of single flat sheets secured to the box proper by screws, or bolts instead of hinges. Boxes having covers of this form are for use only for enclosing joints in conductors or to facilitate the drawing in of wires and cables. They are not intended to enclose switches, cutouts or other control devices.

370-21. Covers. Metal covers shall be of a thickness not less than that specified for the walls of the box or fitting of the same material and with which they are designed to be used, or shall be lined with firmly attached insulating material not less than 1/32 inch in thickness. Covers of porcelain or other approved insulating material may be used when of such form and thickness as to afford the requisite protection and strength.

370-22. Bushings. Covers of outlet boxes and outlet fittings having holes through which flexible cord pendants may pass, shall be provided with approved bushings or shall have smooth, well-rounded surfaces, upon which the cord may bear. Where conductors other than flexible cord may pass through a metal cover, there shall be provided a separate hole for each wire, said hole being equipped with a bushing of suitable insulating material.

370-23. Nonmetallic Boxes. Provisions for supports, or other mounting means, for nonmetallic boxes, shall be outside of the box, or the box shall be so constructed as to prevent contact between the conductors in the box and the supporting screws.

ARTICLE 373 — CABINETS AND CUTOUT BOXES

373-1. Scope. The provisions of this Article shall apply to the installation of cabinets and cutout boxes. Installations in hazardous locations shall conform to the provisions of Articles 500 to 517 inclusive.

A. Installation

373-2. Damp or Wet Locations. In damp or wet locations, cabinets and cutout boxes of the surface type shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the cabinet or cutout box, and shall be mounted so there is at least ¼ inch air space between the enclosure and the wall or other supporting surface. Cabinets or cutout boxes installed in wet locations shall be weatherproof.

373-3. Position in Wall. In walls of concrete, tile, or other noncombustible material, cabinets shall be so installed that the front edge of the cabinet will not set back of the finished surface more than ¼ inch. In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or project therefrom.

373-4. Unused Openings. Unused openings in cabinet or cutout boxes shall be effectively closed to afford protection substantially equivalent to that of the wall of the cabinet or cutout box. Where metal plugs or plates are used with nonmetallic cabinets or cutout boxes, they shall be recessed at least ¼ inch from the outer surface.

373-5. Conductors Entering Cabinets or Cutout Boxes. Conductors entering cabinets or cutout boxes shall be protected from abrasion and shall conform to the following:

(a) Openings To Be Closed. Openings through which conductors enter shall be adequately closed.

(b) Metal Cabinets and Cutout Boxes. Where metal cabinets or cutout boxes are installed with open wiring or concealed knob-and-tube work, conductors shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the cabinet or cutout box.

373-6. Deflection of Conductors. Conductors entering or leaving cabinets or cut out boxes and the like shall conform to the following:

Table 373-6(a)—Minimum Bending Space in Inches

AWG or Circular-Mil Size of Wire	Wires per Terminal 1	2	3	4	5
14 – 8	Not Specified	—	—	—	—
6	1 – ½	—	—	—	—
4 – 3	2	—	—	—	—
2	2½	—	—	—	—
1	3	—	—	—	—
0 – 00	3½	—	—	—	—
000 – 0000	4	6	8	—	—
250 MCM	4½	6	8	10	—
300 – 350 MCM	5	8	10	12	—
400 – 500 MCM	6	8	10	12	14
600 – 700 MCM	8	10	12	14	16
750 – 900 MCM	8	—	—	—	—
1,000 – 1,250 MCM	10	—	—	—	—
1,500 – 2,000 MCM	12	—	—	—	—

(a) Width of Gutters. Conductors shall not be deflected within a cabinet unless a gutter having a width in accordance with Table 373-6(a) is provided.

(b) Insulation at Bushings. Where ungrounded conductors of No. 4 or larger enter a raceway in a cabinet, pull box, junction box, or auxiliary gutter, the conductors shall be protected by a substantial bushing providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway fitting by substantial insulating material securely fastened in place. Where conduit bushings are constructed wholly of insulating material, a locknut shall be installed both inside and outside the enclosure to which the conduit is attached.

373-7. Space in Enclosures. Cabinets and cutout boxes shall conform to the following:

(a) To Accommodate Conductors. Cabinets and cutout boxes shall be selected which have sufficient space to accommodate all conductors installed in them without crowding.

373-8. Switch Enclosures. Switch enclosures shall not be used as junction boxes, auxiliary gutters or raceways for conductors feeding through or tapping off to other switches unless designs suitable for the purpose are employed to provide adequate space for this purpose.

373-9. Side or Back Wiring Spaces or Gutters. Cabinets and cutout boxes shall be provided with back wiring spaces, gutters, or wiring compartments as required by Section 373-11(c and d).

B. Construction Specifications

373-10. Material. Cabinets and cutout boxes shall conform to the following:

(a) Metal Cabinets and Boxes. Metal cabinets and cutout boxes shall be well galvanized, plated with cadmium or other approved metallic finish, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

(b) Strength. The design and construction of cabinets and cutout boxes shall be such as to secure ample strength and rigidity. If constructed of sheet steel, the metal shall be of not less than No. 16 US gage (.0598 inch) in thickness.

(c) Composition Cabinets. Composition cabinets shall be submitted for approval prior to installation.

373-11. Spacing. The spacing within cabinets and cutout boxes shall conform to the following:

(a) General. The spacing within cabinets and cutout boxes shall be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of devices and apparatus mounted within them as follows:

(1) Base. There shall be an air space of at least 1/16 inch, except at points of support, between the base of the device and the wall of any metal cabinet or cutout box in which the device is mounted.

(2) Doors. There shall be an air space of at least 1 inch between any live metal part (including live metal parts of enclosed fuses) and the door, unless the door is lined with an approved insulating material or is of a thickness of metal not less than No. 12 USS gage (.1046 inch), when the air space shall be not less than ½ inch.

(3) Doors and Walls — Link Fuses. There shall be a space of at least 2 inches between open link fuses and metal-lined walls or metal, metal-lined or glass-paneled doors.

(4) Live Parts. Except as noted above, there shall be an air space of at least ½ inch between the walls, back, gutter partition, if of metal, or door of any cabinet or cutout box and the nearest exposed current-carrying part of devices mounted within the cabinet where the potentials do not exceed 250 volts. This spacing shall be increased to at least one inch where the potentials exceed 250 volts.

(b) Switch Clearance. Cabinets and cutout boxes shall be deep enough to allow the closing of the doors when 30-ampere branch-circuit panelboard switches are in any position, or when combination cutout switches are in any position, or when other single-throw switches are opened as far as their construction will permit.

(c) Wiring Space. Cabinets and cutout boxes which contain devices or apparatus connected within the cabinet or box to more than 8 conductors, including those of branch circuits, meter loops, sub-feeder circuits, power circuits and similar circuits, but not including the supply circuit or a continuation thereof, shall have back wiring spaces or one or more side wiring spaces, side gutters or wiring compartments.

(d) Wiring Space — Enclosure. Side wiring spaces, side gutters or side wiring compartments of cabinets and cutout boxes shall be rendered tight enclosures by means of covers, barriers or partitions extending from the bases of the devices, contained in the cabinet, to the door, frame, or sides of the cabinet; provided, however, that where the enclosure contains only those conductors which are led from the cabinet at points directly opposite their terminal connections to devices within the cabinet, such covers, barriers or partitions may be omitted. Partially enclosed back wiring spaces shall be provided with covers to complete enclosure. Wiring spaces that are required by Section 373-11(c) and which are exposed when doors are open, shall be provided with covers to complete the enclosure.

ARTICLE 374 — AUXILIARY GUTTERS

374-1. Purpose. Auxiliary gutters, used to supplement wiring spaces at meter centers, distribution centers, switchboards and similar points of wiring systems, may enclose conductors or bus-bars, but shall not be used to enclose switches, overcurrent devices, appliances or other similar equipment.

374-2. Extension Beyond Equipment. An auxiliary gutter shall not extend a greater distance than 30 feet beyond the equipment which it supplements except in elevator work. Any extension beyond this distance shall comply with the provisions for wireways in Article 362 or with the provisions for busways in Article 364.

374-3. Supports. Gutters shall be supported throughout their entire length at intervals not exceeding 5 feet.

374-4. Covers. Covers shall be securely fastened to the gutter.

374-5. Number of Conductors. Auxiliary gutters shall not contain more than 30 conductors at any cross section unless the conductors are for signal circuits or are controller conductors between a motor and its starter and used only for starting duty. The sum of the cross-sectional areas of all contained conductors at any cross section of an auxiliary gutter shall not exceed 20 per cent of the interior cross-sectional area of the gutter.

For elevators see Section 620-35.

374-6. Ampacity of Conductors. The ampacities of insulated copper and aluminum conductors are given in Tables 310-12 and 310-14 respectively. The correction factors specified in Note 8 of these tables shall not apply to conductors in auxiliary gutters. The current carried continuously in bare copper bars in auxiliary gutters shall not exceed 1000 amperes per square inch of cross section of the conductor. For aluminum bars the current carried continuously shall not exceed 700 amperes per square inch of cross section of the conductor.

374-7. Clearance of Bare Live Parts. Bare conductors shall be securely and rigidly supported so that the minimum clearance between bare current-carrying metal parts of opposite polarities mounted on the same surface shall be not less than 2 inches, nor less than 1 inch for parts that are held free in the air. A clearance not less than 1 inch shall be secured between bare current-carrying metal parts and any metal surface. Adequate provisions shall be made for the expansion and contraction of bus-bars.

374-8. Splices and Taps. Splices and taps shall conform to the following:

(a) Splices or taps, made and insulated by approved methods, may be located within gutters when they are accessible by means of removable covers or doors. The conductors, including splices and taps, shall not fill the gutter to more than 75 per cent of its area.

(b) Taps from bare conductors shall leave the gutter opposite their terminal connections and conductors shall not be brought in contact with uninsulated current-carrying parts of opposite polarity.

(c) All taps shall be suitably identified at the gutter as to the circuit or equipment which they supply.

(d) Tap connections from conductors in auxiliary gutters shall be provided with overcurrent protection in conformity with the provisions of Section 240-15.

374-9. Construction and Installation. Auxiliary gutters shall be constructed in accordance with the following:

(a) Gutters shall be so constructed and installed that adequate electrical and mechanical continuity of the complete system will be secured.

(b) Gutters shall be of substantial construction and shall provide a complete enclosure for the contained conductors. All surfaces, both interior and exterior, shall be suitably protected from corrosion. Corner joints shall be made tight and where the assembly is held together by rivets or bolts, these shall be spaced not more than 12 inches apart.

(c) Suitable bushings, shields or fittings having smooth rounded edges shall be provided where conductors pass between gutters, through partitions, around bends, between gutters and cabinets or junction boxes and at other locations where necessary to prevent abrasion of the insulation of the conductors.

(d) Gutters shall be constructed of sheet metal of thicknesses not less than in the following table:

Table 374-9(d)

Maximum Width of the Widest Surface of Gutters	Thickness (Manufacturers Standard Gage)
Up to and including 6 inches	No. 16; 0.0598 inch
Over 6 in. and not over 18 in.	No. 14; 0.0747 inch
Over 18 in. and not over 30 in.	No. 12; 0.1046 inch
Over 30 inches	No. 10; 0.1345 inch

(e) Where insulated conductors are deflected within the auxiliary gutter, either at the ends or where conduits, fittings or other raceways enter or leave the gutter, or where the direction of the gutter is deflected greater than 30 degrees, dimensions corresponding to Section 373-6 shall apply.

(f) Auxiliary gutters intended for outdoor use shall be of approved raintight construction.

ARTICLE 380 — SWITCHES

A. Installation

380-1. Grounded Conductors. No switch or circuit breaker shall disconnect the grounded conductor of a circuit unless the switch or circuit breaker simultaneously disconnects the ungrounded conductor or conductors, or unless the switch or circuit breaker is so arranged that the grounded conductor cannot be disconnected until the ungrounded conductor or conductors have first been disconnected.

380-2. Three-Way and Four-Way Switches. Three-way and four-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Wiring between switches and outlets shall, where in metal enclosures, be run with both polarities in the same enclosure.

380-3. Enclosures. Switches and circuit breakers shall be of the externally operable type enclosed in metal boxes or cabinets, except pendant and surface type snap switches and knife switches mounted on an open face switchboard or panelboard.

380-4. Wet Locations. A switch or circuit breaker in a wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet installed to conform to Section 373-2.

380-5. Time Switches, Flashers, and Similar Devices. Time switches, flashers, and similar devices need not be of the externally operable type. They shall be enclosed in metal boxes or cabinets except:

Exception No. 1. Where mounted on switchboards or control panels.

Exception No. 2. Where enclosed in approved individual housings.

380-6. Position of Knife Switches. Single-throw knife switches shall be so placed that gravity will not tend to close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred, but where the throw be vertical a locking device shall be provided which will insure the blades remaining in the open position when so set.

380-7. Connection of Knife Switches. Knife switches, unless of the double-throw type, shall be so connected that the blades are dead when the switch is in the open position.

380-8. Accessibility and Grouping. Switches and circuit breakers, so far as practicable, shall be readily accessible and shall be grouped.

Snap switches shall not be grouped or ganged in outlet boxes unless they can be so arranged that the voltage between exposed live metal parts of adjacent switches does not exceed 300 volts.

380-9. Covers of Flush Snap Switches. Flush snap switches, that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces, shall be provided with covers of nonconducting, noncombustible material. Metallic faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but may be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

380-10. Mounting of Surface-Type Snap Switches. Snap switches used with open wiring on insulators shall be mounted on sub-bases of insulating material which will separate the conductors at least ½ inch from the surface wired over.

380-11. Circuit Breakers as Switches. A circuit breaker operable directly by applying the hand to a lever or handle may serve as a switch provided it has the number of poles required for such switch.

380-12. Grounding of Enclosures. Enclosures for switches or circuit breakers on circuits of over 150 volts to ground shall be grounded in the manner specified in Article 250, except where accessible to qualified operators only.

380-13. Knife Switches.

(a) Knife switches rated for more than 1200 amperes at 250 volts or less, and for more than 600 amperes at 251 to 600 volts, shall be used only as isolating switches and shall not be opened under load.

(b) To interrupt currents greater than 1200 amperes at 250 volts or less, or 600 amperes at 251 to 600 volts, a circuit breaker or a switch of special design approved for such purpose shall be used.

(c) Knife switches of lower rating may be used as general-use switches and may be opened under load.

(d) Motor-circuit switches (see Definition) may be of the knife-switch type.

380-14. Rating of Snap Switches. Snap switches installed for the following types of loads shall be rated as follows:

(a) Noninductive Loads. For noninductive loads other than tungsten-filament lamps, switches shall have an ampere rating not less than the ampere rating of the load.

(b) Tungsten Filament Loads. For tungsten-filament lamp load and for combined tungsten-filament and noninductive loads, switches shall be "T" rated or, where on alternating-current circuits, may be a general use alternating-current snap switch.

Exception. A switch that is not "T" rated may be installed to control such loads provided all three of the following qualifications are satisfied:

(1) Where switches are used in branch circuit wiring systems in private homes; in rooms in multiple-occupancy dwellings used only as living quarters by tenants; in private hospital or hotel rooms; or in similar locations but not in public rooms or places of assembly; and

(2) Only where such a switch controls permanently connected fixtures or lighting outlets in one room only, or in one continuous hallway where the lighting fixtures may be located at different levels, or on porches or in attics or basements not used for assembly purposes; and

(3) The switch is rated at not less than 10A, 125V; 5A, 250V; or for the 4-way types, 5A,125 V; 2A, 250V.

(c) Inductive Loads. Switches controlling inductive loads shall have an ampere rating twice the ampere rating of the load unless they are of a type approved as part of an assembly or for the purpose employed. On alternating-current circuits, general use alternating-current snap switches may be used to control inductive loads other than motors not exceeding the ampere rating of the switch.

For switches on signs and outline lighting, see Section 600-2.
For switches controlling motors, see Sections 430-83 and 430-110.

B. Construction Specifications

380-15. Marking. Switches shall be marked with the current and voltage and, if horsepower rated, the maximum rating for which they are designed.

380-16. 600-Volt Knife Switches. Auxiliary contacts of a renewable or quick-break type or the equivalent, shall be provided on all 600-volt knife switches designed for use in breaking currents over 200 amperes.

Auxiliary contacts shall be provided on direct-current switches rated at over 250 volts.

380-17. Multiple Fuses. Switches rated above 600 amperes may be arranged for fuses in multiple provided as few fuses as possible are used and the fuses are of the same type and rating and are so mounted as to eliminate a potential difference between the terminals of the fuses. (See Section 240-14.)

ARTICLE 384 — SWITCHBOARDS AND PANELBOARDS

384-1. Scope. The requirements of this Article shall apply to all switchboards, panelboards, and distribution boards installed for the control of light and power circuits.

Exception No. 1. Switchboards in utility company operated central stations or substations, which directly control energy derived from generators or transforming devices.

Exception No. 2. Switchboards or portions thereof used exclusively to control signal circuits operated by batteries.

The requirements of this Article shall apply to battery-charging panels where current is taken from light or power circuits.

384-2. Application of Other Articles. Switches, circuit breakers and overcurrent devices used on switchboards, panelboards and distribution boards, the boards and their enclosures, shall conform to the requirements of Articles 240, 250, 370, 380 and other Articles which apply. Switchboards and panelboards in hazardous locations shall conform to the requirements of Articles 500 to 517 inclusive.

384-3. Support and Arrangement of Bus-bars and Conductors.

(a) Conductors and bus-bars on a switchboard, panelboard or control board shall be so located as to be free from physical damage and shall be held firmly in place.

(b) The arrangement of bus-bars and conductors shall be such as to avoid overheating due to inductive effects.

(c) Each switchboard, switchboard section or panelboard, if used as service equipment, shall be provided with an equipment grounding means placed within the service disconnect section for connecting the neutral on its supply side to the switchboard or panelboard frame. The equipment grounding means for switchboards or panelboards rated more than 225 amperes shall have a cross sectional area of at least 25% of the cross sectional area of the service entrance conductors, but need not exceed the cross sectional area of the grounding conductors specified in Table 250-94(a).

It is recommended that the switchboard, if consisting of more than one section, be provided with a copper ground bus, and equipment ground strap be connected to the switchboard ground bus.

A. Switchboards

384-4. Location of Switchboards. Switchboards which have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified persons.

384-5. Wet Locations. Where a switchboard is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to conform to Section 373-2.

384-6. Location Relative to Easily Ignitible Material. Switchboards shall be so placed as to reduce to a minimum the probability of communicating fire to adjacent easily ignitible material.

384-7. Clearance from Ceiling. Switchboards shall not be built up to a nonfireproof ceiling, a space of 3 feet being left between the ceiling and the board, unless an adequate fireproof shield is provided between the board and the ceiling.

384-8. Clearance Back of Switchboard. Clearances around switchboards shall conform to the provisions for Working Space about Electrical Equipment as specified in Section 110-16 of this Code.

384-9. Conductor Covering. Insulated conductors where closely grouped, as on the rear of switchboards, shall each have a flame-retardant outer covering. The conductor covering shall be stripped back a sufficient distance from the terminals so as to not make contact with them. Insulated conductors used for instrument and control wiring on the back of switchboards shall be flame-retardant, either inherently or by means of an outer covering, such as one of the following types: R, RH, RW, RHH, RHW, V, ALS, AVA, AVB, SIS, T, TA, TBS, TW, THW, MI, or other types specifically approved for the purpose.

384-11. Grounding Switchboard Frames. Switchboard frames and structures supporting switching equipment shall be grounded, except that frames of direct-current single-polarity switchboards need not be grounded if effectively insulated.

384-12. Grounding of Instruments, Relays, Meters and Instrument Transformers on Switchboards. Instruments, relays, meters and instrument transformers located on switchboards shall be grounded as specified in Sections 250-121 to 250-125.

B. Panelboards

384-13. General. All panelboards shall have a rating not less than the minimum feeder capacity required for the load as computed from Article 220. Panelboards shall be durably marked by the manufacturer with the voltage and the current rating and the number of phases for which they are designed and with the manufacturer's name or trademark in such a manner as to be visible after installation, without disturbing the interior parts or wiring.

384-14. Lighting and Appliance Branch Circuit Panelboard. For the purposes of this Section, a lighting and appliance branch circuit panelboard is one having more than 10 per cent of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

384-15. Number of Overcurrent Devices on One Panelboard. Not more than 42 overcurrent devices (other than those provided for in the mains) of a lighting and appliance branch circuit panelboard shall be installed in any one cabinet or cutout box.

A lighting and appliance branch circuit panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated and approved.

For the purposes of this Article a two-pole circuit breaker shall be considered two overcurrent devices; a three-pole breaker shall be considered three overcurrent devices.

384-16. Overcurrent Protection.

(a) Each lighting and appliance branch circuit panelboard shall be individually protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating not greater than that of the panelboard.

Exception No. 1. Individual protection for a lighting and appliance panelboard is not required when the panelboard feeder has overcurrent protection not greater than that of the panelboard.

Exception No. 2. Individual protection for lighting and appliance branch circuit panelboards is not required where such panelboards are used as service equipment in supplying an individual residential occupancy and where any bus supplying 15 or 20 ampere circuits is protected on the supply side by an overcurrent device.

(b) Panelboards equipped with snap switches rated at 30 amperes or less, shall have overcurrent protection not in excess of 200 amperes.

(c) The total load on any overcurrent device located in a panelboard shall not exceed 80% of its rating where in normal operation the load will continue for 3 hours or more.

Exception. Except where the assembly including the overcurrent device is approved for continuous duty at 100% of its rating.

384-17. Panelboards in Damp or Wet Locations. Panelboards in damp or wet locations shall be installed in conformity to Section 373-2.

384-18. Enclosure. Panelboards shall be mounted in cabinets or cutout boxes.

384-19. Relative Arrangement of Switches and Fuses. Panelboards having switches on the load side of any type of fuses shall not be installed except for use as service equipment as provided in Section 230-94.

C. Construction Specifications

384-20. Panels. The panels of switchboards shall be made of moisture-resistant, noncombustible material.

384-21. Bus-bars. Bus-bars may be of bare metal provided they are rigidly mounted.

384-22. Protection of Instrument Circuits. Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils, except where the operation of the overcurrent device might introduce a hazard in the operation of devices, shall be supplied by a circuit that is protected by standard overcurrent devices of a rating not greater than 15 amperes, except that for ratings of 2 amperes or less special types of enclosed fuses may be used.

384-23. Component Parts. Switches, fuses, and fuseholders used on panelboards shall conform to the requirements of Articles 240 and 380 so far as they apply.

384-24. Knife Switches. Knife switches shall be so arranged that the blades, when exposed during operation, will be dead when the switches are open.

384-25. Color-Coding. On switchboards or panelboards that are provided with color markings to indicate the main bus-bars to which branch circuit bus-bars are connected, the colors shall conform to the color coding of Section 210-5.

384-26. Spacings. Except at switches and circuit breakers, the distance between bare metal parts, bus-bars, etc., shall be not less than specified in the following Table:

Table 384-26—Spacings Between Bare Metal Parts

	Opposite Polarity When Mounted on the Same Surface	Opposite Polarity When Held Free in Air	*Live Parts to Ground
Not over 125 volts	¾ inch	½ inch	½ inch
Not over 250 volts	1¼ inch	¾ inch	½ inch
Not over 600 volts	2 inches	1 inch	1 inch

*For spacing between live parts and doors of cabinets, see subparagraph a of Section 373-11.

It should be noted that the above distances are the minimum allowable, and it is recommended that greater distances be provided wherever the conditions will permit.

At switches, enclosed fuses, etc., parts of the same polarity may be placed as close together as convenience in handling will allow, unless close proximity causes excessive heating.

ARTICLE 390 — PREFABRICATED BUILDINGS

390-1. Scope. The intent and purpose of the following sections is to define approved methods for the wiring of prefabricated building sections, panels, or units designed for later erection or assembly as integral parts of buildings whether wired in the process of manufacture or at the site of erection or assembly.

390-2. Wiring Methods. Only wiring methods recognized in this Code shall be used.

390-3. Code Provisions to Apply. The provisions of this Code shall apply for the type of wiring method used and the type of construction employed.

Chapter 4. Equipment for General Use

ARTICLE 400 — FLEXIBLE CORDS

A. General and Types

400-1. General. Flexible cords shall be suitable for the conditions of use and location.

400-2. Types. Cords of the several types shall conform to the descriptions of Table 400-11. Types of flexible cords other than those listed in Table 400-11 and other uses for types listed in the Table, shall be the subject of special investigations and shall not be used before being approved.

B. Use and Installation

400-3. Use. Flexible cord may be used only for (1) pendants; (2) wiring of fixtures; (3) connection of portable lamps or appliances; (4) elevator cables; (5) wiring of cranes and hoists; (6) connection of stationary equipment to facilitate their frequent interchange; or (7) prevention of the transmission of noise or vibration; or (8) facilitating the removal or disconnection of fixed appliances for maintenance or repair.

400-4. Prohibited Uses. Flexible cord shall not be used (1) as a substitute for the fixed wiring of a structure; (2) where run through holes in walls, ceilings, or floors; (3) where run through doorways, windows, or similar openings; (4) where attached to building surfaces; or (5) where concealed behind building walls, ceilings, or floors.

400-5. Splices. Flexible cord shall be used only in continuous lengths without splice or tap.

400-6. Cords in Show-Windows and Show-Cases. Flexible cord used in show-windows and show-cases shall be of types S, SO, SJ, SJO, ST, SJT, or AFS, except for the wiring of chain supported fixtures, and for supplying current to portable lamps and other merchandise for exhibition purposes.

400-7. Minimum Size. Flexible cords shall not be smaller than No. 18, except that tinsel cords, or cords having equivalent characteristics, of smaller size may be approved for use with specific appliances.

400-8. Insulation—Over 300 Volts. Where the voltage between any two conductors exceeds 300, but does not exceed 600, flexible cord of No. 10 and smaller shall have rubber or thermoplastic insulation on the individual conductors at least 3/64 inch in thickness, unless type S, SO or ST cord is used.

400-9. Overcurrent Protection and Ampacities of Flexible Cords.

(a) Overcurrent Protection. Flexible cords not smaller than No. 18, and tinsel cords, or cords having equivalent characteristics, of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent by the overcurrent devices described in Section 240-5. Cords shall be not smaller than required in Table 400-9 (b) for the rated current of the connected equipment.

Table 400-9(b). Ampacity of Flexible Cord

Table 400-9(b) gives the allowable ampacity for not more than three current carrying conductors in a cord. If the number of current carrying conductors in a cord is from four to six, the allowable ampacity of each conductor shall be reduced to 80 per cent of the values in the Table. The ampacities for the sizes and types of three conductor cords connected to utilization equipment, where the third conductor is used for equipment grounding only and does not carry any load current, are given in Notes 1 and 2 following the Table.

(Based on Room Temperature of 30°C (86°F.). See Section 400-9 and Table 400-11.)

Size AWG	Rubber Types TP, TS Thermoplastic Types TPT, TSP	Rubber Types PO, C, PD, P, K, E, EO Thermoplastic Type ET	Rubber Types S, SO, SRD, SJ, SJO, SV, SVO, SP Thermoplastic Types ST, STO, SRDT, SJT, SJTO, SVT, SVTO, SPT	Types AFS, AFSJ, HC, HPD, HSJ, HSJO, HS, HSO, HPN	Types AVPO, AVPD	Cotton Types CFC* CFPO* CFPD* Asbestos Types AFC* AFPO* AFPD*
27**	0.5	..	..	..	..	..
18	...	5	7	10	17	6
17	...	..	..	12	..	..
16	...	7	10	15	22	8
15	...	..	..	17	..	..
14	...	15	15	20	28	17
12	...	20	20	30	36	23
10	...	25	25	35	47	28
8	...	35	35	..	..	..
6	...	45	45	..	..	..
4	...	60	60	..	..	..
2	...	80	..	..	..	..

*These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.

**Tinsel cord.

Note 1. For Nos. 18, 16 and 14 AWG sizes of Types S, SO and ST Cords, the allowable ampacities are 10, 13 and 18 amperes respectively.

Note 2. For Nos. 18 and 16 AWG sizes of SJ, SJO and SJT Cords, the allowable ampacities are 10 and 13 amperes respectively.

Note 3. Ultimate Insulation Temperature. In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of the conductors will be exceeded.

400-10. Pull at Joints and Terminals. Flexible cords shall be so connected to devices and to fittings that tension will not be transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, winding with tape, by a special fitting designed for that purpose, or by other approved means which will prevent a pull on the cord from being directly transmitted to joints or terminal screws.

Notes to Table 400-11

1. Except for Types AFPO, CFPO, PO-1, PO-2, PO, SP-1, SP-2, SPT-1, SPT-2, TP, TPT, and AVPO, individual conductors are twisted together.

2. Type PO-1 is for use only with portable lamps, portable radio receiving appliances, portable clocks and similar appliances which are not liable to be moved frequently and where appearance is a consideration.

3. Types TP, TPT, TS, and TST are suitable for use in lengths not exceeding eight feet when attached directly, or by means of a special type of plug, to a portable appliance rated at 50 watts or less and of such nature that extreme flexibility of the cord is essential.

4. Type K is suitable for use on theatre stages.

5. Rubber-filled or varnished cambric tapes may be substituted for the inner braids.

6. Types S, SO, and ST are suitable for use on theatre stages, in garages and elsewhere, where flexible cords are permitted by this Code.

7. Traveling cables for operating, control and signal circuits may have one or more nonmetallic fillers or may have a supporting filler of stranded steel wires having its own protective braid or cover. Cables exceeding 100 feet in length shall have steel supporting fillers, except in locations subject to excessive moisture or corrosive vapors or gases. Where steel supporting fillers are used, they shall run straight through the center of the cable assembly and shall not be cabled with the copper strands of any conductor.

Type E and EO Cables may incorporate in the construction #20 Gauge Conductors formed as a pair, and covered with suitable metallic braided shielding for telephone circuits. The insulation of the conductors may be rubber or thermoplastic of thickness specified for Type E and EO Cables. The shield shall have its own protective covering. This component may be incorporated in any layer of the cable assembly, and shall not run straight through the center.

8. A third conductor in these cables is for grounding purposes only.

9. The individual conductors of all cords except those of heat-resistant cords (Types AFC, AFPO, AFPD, AFS, AFSJ, AVPO, AVPD, CFC, CFPO and CFPD) shall have a rubber or thermoplastic insulation, except that the grounding conductor where used, shall be in accordance with Paragraph 400-14(b). A rubber compound shall be vulcanized except for heater cords (Types HC, HPD and HSJ) and for belt fillers in Types P-1, P-2, and P.

Table 400-11. Flexible Cord.

(See Section 400-2)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Parallel Tinsel Cord	TP See Note 3	27	2	Rubber	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TPT See Note 3	27	2	Thermoplastic	None	Thermoplastic	Attached to an Appliance	Damp Places	Not Hard Usage
Jacketed Tinsel Cord	TS See Note 3	27	2 or 3	Rubber	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TST See Note 3	27	2 or 3	Thermoplastic	None	Thermoplastic	Attached to an Appliance	Damp Places	Not Hard Usage
Asbestos-Covered Heat-Resistant Cord	AFC	18–10	2 or 3	Impregnated Asbestos	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	AFPO		2		None	Cotton, Rayon or Saturated Asbestos			
	AFPD		2 or 3						
Cotton-Covered Heat-Resistant Cord	CFC	18–10	2 or 3	Impregnated Cotton	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	CFPO		2		None	Cotton or Rayon			
	CFPD		2 or 3						

See Notes

Parallel Cord	PO–1	18	2	Rubber	Cotton	Cotton or Rayon	See Note 2 Pendant or Portable	Dry Places	Not Hard Usage
	PO–2	18–16							
	PO	18–10							
All Rubber Parallel Cord	SF–1	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	Not Hard Usage
	SP–2 See Note 8	18–16							
	SP–3 Note 8	18–12		Rubber	None	Rubber	Refrigertors or Room Air Conditioners	Damp Places	Not Hard Usage
All Plastic Parallel Cord	SPT–1	18	2	Thermoplastic	None	Thermoplastic	Pendant or Portable	Damp Places	Not Hard Usage
	SPT–2 See Note 8	18–16							
All Plastic Parallel Cord	SPT–3 Note 8	18–10	2	Thermoplastic	None	Thermoplastic	Refrigerators or Room Air Conditioners	Damp Places	Not Hard Usage
Lamp Cord	C	18–10	2 or more	Rubber	Cotton	None	Pendant or Port.	Dry Places	NotHard Usage
Twisted Portable Cord	PD	18–10	2 or more	Rubber	Cotton	Cotton or Rayon	Pendant or Port.	Dry Places	NotHard Usage

See Notes

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Reinforced Cord	P–1	18	2 or more	Rubber	Cotton	Cotton over Rubber Filler	Pendant or Portable	Dry Places	NotHard Usage
	P–2	18–16							Hard Usage
	P	18–10							
Braided Heavy Duty Cord	K See Note 4	18–10	2 or more	Rubber	Cotton	Two Cotton, Moisture-Resistant Finish See Note 5	Pendant or Portable	Damp Places	Hard Usage
Vacuum Cleaner Cord	SV, SVO	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	NotHard Usage
	SVT, SVTO See Note 8			Thermopl'		Thermoplastic			
Junior Hard Service Cord	SJ	18–16	2, 3, or 4	Rubber	None	Rubber	Pendant or Portable	Damp Places	Hard Usage
	SJO					Oil Resistant Compound			
	SJT SJTO			Thermopl' or Rubber		Thermoplastic			

See Notes

Hard Service Cord	S See Note 6	18–2	2 or more	Rubber	None	Rubber	Pendant or Portable	Damp Places	Extra Hard Usage
	SO					Oil Resist. Compound			
	ST			Thermopl' or Rubber		Thermoplastic			
	STO					Oil Resistant Thermoplastic			
Rubber-Jacketed Heat-Resistant Cord	AFSJ	18–16	2 or 3	Impregnated Asbestos	None	Rubber	Portable	Damp Places	Portable Heaters
	AFS	18-16-14							
Heater Cord	HC	18–12	2, 3 or 4	Rubber & Asbestos	Cotton	None	Portable	Dry Places	Portable Heaters
	HPD	18–12	2, 3 or 4	Rubber with Asbestos or All Neoprene	None	Cotton or Rayon			
Rubber Jacketed Heater Cord	HSJ	18–16	2, 3 or 4	Rubber with Asbestos or All Neoprene	None	Cotton and Rubber	Portable	Damp Places	Portable Heaters
Jacketed Heater Cord	HSJO	18–16	2, 3 or 4	Rubber with Asbestos or All Neoprene	None	Cotton and Oil Resistant Compound	Portable	Damp Places	Portable Heaters
	HS	14–12				Cotton and Rubber or Neoprene			
	HSO	14–12				Cotton and Oil Resistant Compound			

See Notes

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Parallel Heater Cord	HPN	18–16	2	Thermosetting	None	Thermosetting	Portable	Damp Places	Portable Heaters
Heat & Moisture-Resistant Cord	AVPO	18–10	2	Asbestos & Var. Cam.	None	Asbestos, Flame-Ret. Moisture Resistant	Pendant or Portable	Damp Places	Not Hard Usage
	AVPD		2 or 3						
Range, Dryer Cable	SRD	10–4	3 or 4	Rubber	None	Rubber or Neoprene	Portable	Damp Places	Ranges, Dryers
	SRDT	10–4	3 or 4	Thermoplastic	None	Thermoplastic	Portable	Damp Places	Ranges, Dryers
Elevator Cable	E See Note 7	18–14	2 or more	Rubber	Cotton	Three Cotton, Outer one Flame-Retardant & Moisture-Resist. See Note 5	Elevator Lighting and Control	Non-Hazardous Locations	
	EO See Note 7					One Cotton and a Neoprene Jacket See Note 5		Hazardous Locations	
	ET See Note 7	18–14		Thermoplastic	Rayon	Three cotton, Outer one Flame-Retardant & Moisture-Resistant. See Note 5		Non-Hazardous Locations	

See Notes

C. Construction Specifications

400-12. Labels. Flexible cords shall be examined and tested at the factory and shall be labeled before shipment.

400-13. Grounded Conductor Identification. One conductor of flexible cords shall have a continuous marker readily distinguishing it from the other conductor or conductors. The identification shall consist of one of the following:

(a) Colored Braid. A braid finished to show a white or natural gray color and the braid on the other conductor or conductors finished to show a readily distinguishable solid color or colors.

(b) Tracer in Braid. A tracer in a braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors. No tracer shall be used in the braid of any conductor of a flexible cord which contains a conductor having a braid finished to show white or natural gray, except, in the case of Types C, PD and PO cords having the braids on the individual conductors finished to show white or natural gray. In such C, PD and PO cords the identifying marker may consist of the solid white or natural gray finish on one conductor provided there is a colored tracer in the braid of each other conductor.

(c) Colored Insulation. A white or natural gray insulation on one conductor and insulation of a readily distinguishable color or colors on the other conductor or conductors for cords having no braids on the individual conductors (except cords which have insulation on the individual conductors integral with the jacket). The insulation may be covered with an outer finish to provide the desired color.

(d) Colored Separator. A white or natural gray separator on one conductor and a separator of a readily distinguishable solid color on the other conductor or conductors of cords having insulation on the individual conductors integral with the jacket.

(e) Tinned Conductors. One conductor having the individual strands tinned and the other conductor or conductors having the individual strands untinned for cords having insulation on the individual conductors integral with the jacket.

(f) Surface Marking. A stripe, ridge or groove so located on the exterior of the cord as to identify one conductor for cords having insulation on the individual conductors integral with the jacket.

400-14. Grounding Conductor Identification. A conductor intended to be used as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. Conductors having a green covering shall not be used for other than grounding purposes. The identifying marker shall consist of one of the following:

(a) Colored Braid. A braid finished to show a continuous green color or a continuous green color with a yellow stripe.

(b) Colored Insulation or Covering. For cords having no braids on the individual conductors a continuous green color insulation or a continuous green color with a yellow stripe covering on one conductor.

400-15. Insulation Thickness. The nominal thickness of rubber or thermoplastic conductor insulation in Types TS, TST, PO-1, P-1, SV, and SVT shall be not less than 1/64 inch. The nominal thickness of rubber insulation in Types HC, HPD, HSJ, and HS shall be not less than 1/64 inch for the Nos. 18-16 AWG sizes, and not less than 2/64 inch for the Nos. 14-12 AWG sizes. For heater cord other than Types HS and HPS, the all Neoprene insulation shall be 2/64 inch for No. 18 and No. 16 AWG sizes and 3/64 inch for No. 14 and No. 12 AWG sizes. The nominal thickness of the thermoplastic insulation in Type ET elevator cable shall be not less than 20 mils for the No. 18 and No. 16 AWG size and not less than 1/32 inch for the No. 14 AWG size. The nominal thickness of the rubber insulation in Types E and EO elevator cables shall be not less than 20 mils for the No. 18 and 16 AWG sizes and not less than 2/64 inch for the No. 14 AWG size for ratings not exceeding 300 volts. The nominal thickness of latex-rubber insulation, when employed, in Types SJ, SJO, S and SO shall be not less than 15 mils for the Nos. 18-16 AWG sizes and not less than 18 mils for the No. 14 AWG and larger sizes. The nominal thickness of conductor insulation in Types PO, P, SP-2, SPT-2, HPN, SRD, and SRDT shall be not less than 3/64 inch. The nominal thickness of thermoplastic insulation in Type SPT-3 shall be not less than 4/64 inch for sizes 18-16 and 5/64 inch for No. 14, 6/64 inch for No. 12 and 7/64 inch for No. 10 AWG. For other types, the minimum nominal thickness of rubber or thermoplastic conductor insulation shall be as follows: size AWG 27, and 18 to 16—2/64 inch; 14 to 10—3/64 inch; 8 to 2—4/64 inch.

400-16. Attached to Receptacle Plugs. Where a flexible cord is provided with a grounding conductor and equipped with an attachment plug, the plug shall comply with Paragraphs 250-59(a and b).

ARTICLE 402 — FIXTURE WIRES

402-1. Use. Fixture wires are designed for installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use. Also, they are used for connecting lighting fixtures to the conductors of the circuit that supplies the fixtures.

For application in lighting fixtures, see Article 410.

Fixture wires are not intended for the connection of portable or stationary appliances, nor for installation as branch circuit conductors, except as permitted in Article 725.

402-2. Minimum Size. Fixture wires shall not be smaller than No. 18.

402-3. Insulation.

(a) The rubber insulations include those made from natural and synthetic rubber, neoprene and other vulcanized materials.

Thermoplastic insulation may stiffen at temperatures below minus 10°C. (14°F.) and care should be used in its installation at such temperatures. It may be deformed when subject to pressure; care should be taken in its installation, as for example, at bushings, or points of support. See Section 373-6(b).

(b) No conductor shall be used under such conditions that its temperature, even when carrying current, will exceed the temperature specified in Table 310-2(a) for the type of insulation involved.

Table 402-4. Allowable Ampacity of Fixture Wire

(Based on Room Temperature of 30°C., 86°F.)

Size AWG	Fixture Wire	
	Rubber Types RF-1, RF-2, FF-1, FF-2, RFH-1, RFH-2, FFH-1, FFH-2	Thermoplastic Types TF, TFF Cotton Type CF* Asbestos Type AF* Silicone Rubber Types SF-1*, SF-2*, SFF-1*, SFF-2*
18	5	6
16	7	8
14	..	17

*These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.

Ultimate Insulation Temperature. In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of the conductors will be exceeded.

402-5. Overcurrent Protection.

See Section 240-5. Exception No. 3.

Table 402-6. Fixture Wire

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Rubber-Covered Fixture Wire Solid or 7-Strand	RF-1	Code Rubber	18..................1/64 Inch	Non-metallic covering
	RF-2	Code Rubber	18–16..............2/64 Inch	Non-metallic covering
		Latex Rubber	18–16................18 Mils	
Rubber-Covered Fixture Wire Flexible Stranding	FF-1	Code Rubber	18..................1/64 Inch	Non-metallic covering
	FF-2	Code Rubber	18–16..............2/64 Inch	Non-metallic covering
		Latex Rubber	18–16................18 Mils	
Heat Resistant Rubber-Covered Fixture Wire Solid or 7-Strand	RFH-1	Heat-Resistant Rubber	18..................1/64 Inch	Non-metallic covering
	RFH-2	Heat-Resistant Rubber	18–16..............2/64 Inch	Non-metallic covering
		Heat-Resistant Latex Rubber	18–16................18 Mils	
Heat Resistant Rubber-Covered Fixture Wire Flexible Stranding	FFH-1	Heat-Resistant Rubber	18..................1/64 Inch	Non-metallic covering
	FFH-2	Heat-Resistant Rubber	18–16..............2/64 Inch	Non-metallic covering
		Heat-Resistant Latex Rubber	18–16................18 Mils	
Thermoplastic-Covered Fixture Wire—Solid or Stranded	TF	Thermoplastic	18–16..............2/64 Inch	None

Continued on next page

Table 402-6 (Continued)

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	Thermoplastic	18–16. . . . . .2/64 Inch	None
Cotton-Covered, Heat-Resistant, Fixture Wire	CF	Impregnated Cotton	18–14. . . . . .2/64 Inch	None
Asbestos-Covered, Heat-Resistant, Fixture Wire	AF	Impregnated Asbestos	18–14. . . . . .2/64 Inch	None
Silicone Insulated Fixture Wire	SF-1	Silicone Rubber	18. . . . . .1/64 Inch	Non Metallic Covering
Solid or 7-Strand	SF-2	Silicone Rubber	18-14. . . . . .1/32 Inch	Non Metallic Covering
Silicone Insulated Fixture Wire	SFF-1	Silicone Rubber	18. . . . . .1/64 Inch	Non Metallic Covering
Flexible Stranding	SFF-2	Silicone Rubber	18-14. . . . . .1/32 Inch	Non Metallic Covering

ARTICLE 410 — LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, RECEPTACLES AND ROSETTES

A. General

410-1. Scope. Lighting fixtures, lampholders, pendants, receptacles, and rosettes, incandescent filament lamps, arc lamps, electric discharge lamps, the wiring and equipment forming part of such lamps, fixtures and lighting installations shall conform to the provisions of this Article, except as otherwise provided in this Code.

410-2. Application to Other Articles. Equipment for use in hazardous locations shall conform to Articles 500 to 517.

410-3. Live Parts. Fixtures, lampholders, lamps, rosettes and receptacles shall have no live parts normally exposed to contact, except in the case of cleat-type lampholders, receptacles and rosettes which are located at least 8 feet above the floor. Lampholders, receptacles and switches which have exposed accessible terminals shall not be installed in metal fixture canopies or in open bases of portable table or floor lamps.

B. Provisions for Fixture Locations

410-4. Fixtures in Damp, Wet or Corrosive Locations.

(a) Fixtures installed in damp or wet locations shall be approved for such locations and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders or other electrical parts. All fixtures installed outdoors, in damp or wet locations shall be marked "Suitable for Wet Locations."

(b) Fixtures installed in corrosive locations shall be of a type approved for such locations.

See Section 210-21 (b) for receptacles in fixtures.

410-5. Fixtures near Combustible Material. Fixtures shall be so constructed, or installed, or equipped with shades or guards that combustible material will not be subjected to temperatures in excess of 90° C (194° F).

410-6. Fixtures over Combustible Material. Lampholders installed over highly combustible material shall be of the unswitched type and unless an individual switch is provided for each fixture, shall be located at least 8 feet above the floor, or shall be otherwise so located or guarded that the lamps cannot be readily removed or damaged.

410-7. Fixtures in Show-Windows. Externally wired fixtures shall not be used in a show-window.

Exception: Fixtures of the chain-supported type may be externally wired.

410-8. Fixtures in Clothes Closets.

(a) A fixture in a clothes closet shall be installed:

(1) On the wall above the closet door, or

(2) On the ceiling over an area which is unobstructed to the floor, or

(3) So that the clearance from the fixture to any combustible material within the closet is not less than 18 inches.

NOTE: A flush recessed fixture equipped with a solid lens is considered to be outside the closet area.

(b) Pendants shall not be installed in clothes closets.

410-9. Space for Cove Lighting. Coves shall have adequate space and shall be so located that lamps and equipment can be properly installed and maintained.

C. Provisions at Fixture Outlet Boxes, Canopies and Pans

410-10. Space for Conductors. Canopies and outlet boxes taken together shall provide adequate space so that fixture conductors and their connecting devices may be properly installed.

410-11. Temperature Limit of Conductors in Outlet Boxes. Fixtures shall be of such construction or so installed that the conductors in outlet boxes shall not be subjected to temperatures greater than that for which the conductors are approved.

410-12. Outlet Boxes to be Covered. In a completed installation, each outlet box shall be provided with a cover unless covered by means of a fixture canopy, lampholder, receptacle, rosette, or similar device.

410-13. Covering of Combustible Material at Outlet Boxes. Any combustible wall or ceiling finish exposed between the edge of a fixture, canopy or pan and an outlet box shall be covered with noncombustible material.

410-14.

CONNECTION OF FIXTURES. In general, fluorescent fixtures when supported independently of the outlet box shall be connected through metal raceways or armored conductors. This requirement may be waived when grounding type cord-equipped fixtures are suspended directly below the outlet box and the exposed cord is not subject to strain or physical damage.

D. Fixture Supports

410-15. Supports—General. Fixtures, lampholders, rosettes and receptacles shall be securely supported. A fixture which weighs more than 6 lbs. or exceeds 16 inches in any dimension shall not be supported by the screw shell of a lampholder.

410-16. Means of Support. Where the outlet box or fitting will provide adequate support, a fixture shall be attached thereto; otherwise a fixture shall be supported as required by Section 370-13. A fixture which weighs more than 50 lbs. shall be supported independently of the outlet box.

E. Wiring of Fixtures

410-17. Fixture Wiring—General. Wiring on or within fixtures shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be so arranged that they shall not be subjected to temperatures above those for which they are approved.

410-18. Conductor Size. Fixture conductors shall not be smaller than No. 18 AWG.

410-19. Conductor Insulation.

(a) Fixtures shall be wired with conductors having insulation suitable for the current, voltage, and temperature to which the conductors will be subjected.

(b) Where fixtures are installed in damp, wet, or corrosive locations, conductors shall be of a type approved for such locations.

(c) For ampacity of fixture wire, see Table 402-4.

(d) For maximum operating temperature and voltage limitation of fixture wires, see Section 310-2.

410-20. Conductors for Certain Conditions.

(a) Fixtures provided with Mogul base screw-shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, SFF-1 or SFF-2 fixture wire.

(b) Fixtures provided with other than Mogul base screw shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, SFF-1, SFF-2 fixture wire or Type AFC, AFPO, or AFPD flexible cord.

Exception No. 1. Where temperatures do not exceed 90° C (194° F), Type CF fixture wire or Type CFC, CFPD, or CFPO flexible cord may be used.

Exception No. 2. Where temperatures exceed 60° C (140° F) but are not higher than 75° C (167° F) Type RH rubber-covered wire, Type RFH-1, RFH-2, FFH-1, and FFH-2 fixture wires may be used.

Exception No. 3. Where temperatures do not exceed 60° C (140° F), Type T thermoplastic wire, Types TF and TFF fixture wire, Type R rubber-covered wire, and Types RF-1, RF-2, FF-1, FF-2 fixture wires may be used, including use in fixtures of decorative type on which lamps of not over 60-watt rating are used in connection with imitation candles.

See Sections 402-6 and 310-2 for fixture wires and conductors; also, Table 400-9(b) for flexible cords.

410-21. Conductors for Movable Parts .

(a) Stranded conductor shall be used for wiring on fixture chains and on other movable or flexible parts.

(b) Conductors shall be so arranged that the weight of the fixture or movable parts will not put a tension on the conductors.

410-22. Pendant Conductors for Incandescent Filament Lamps.

(a) Pendant lampholders with permanently attached leads, where used in other than festoon wiring, shall be hung from separate stranded rubber-covered conductors which are soldered directly to the circuit conductors but supported independently thereof.

(b) Such pendant conductors shall be not smaller than No. 14 AWG for heavy-duty or medium-base screw-shell lampholders, nor, except for approved Christmas tree and decorative lighting outfits, smaller than No. 18 AWG for intermediate or candelabra-base lampholders.

(c) Pendant conductors longer than 3 feet shall be twisted together where not cabled in an approved assembly.

410-23. Protection of Conductors and Insulation.

(a) Conductors shall be secured in a manner that will not tend to cut or abrade the insulation.

(b) Conductor insulation shall be protected from abrasion where it passes through metal.

(c) Fixtures in permanently installed (fixed) showcases or wall cases shall be supplied through a permanent connection to a recognized wiring system. Stationary equipment may be cord-connected as provided in Section 400-3; item (6).

410-24. Conductor Protection at Lampholders. Where a metal lampholder is attached to a flexible cord, the inlet shall be equipped with an insulating bushing which, if threaded, shall not be smaller than nominal ⅜ inch pipe size. The cord hole shall be of a size appropriate for the cord and all burrs and fins removed in order to provide a smooth bearing surface for the cord.

Bushings having holes 9/32 inch in diameter are suitable for use with plain pendant cord and holes 13/32 inch in diameter with reinforced cord.

410-25. Connections, Splices and Taps.

(a) Fixtures shall be so installed that the connections between the fixture conductors and the circuit conductors may be inspected without requiring the disconnection of any part of the wiring, unless the fixture is connected by means of a plug and receptacle.

(b) Splices and taps shall not be located within fixture arms or stems.

(c) No unnecessary splices or taps shall be made within or on a fixture.

(d) For approved means of making connections, see Sections 110-14 and 110-15.

410-26. Fixture Raceways. Fixtures shall not be used as a raceway for circuit conductors unless the fixtures meet the requirements for approved raceways, except that the conductors of the single branch circuit supplying the fixtures may be carried through as follows:

Exception No. 1. An installation of fixtures approved for end to end assembly to form a continuous raceway, or

Exception No. 2. Fixtures which are connected together by approved wiring methods.

Branch circuit conductors within 3 inches of a ballast within the ballast compartment shall be recognized for use at temperatures not lower than 90°C. (194°F.).

410-27. Polarization of Fixtures. Fixtures shall be so wired that the screw-shells of lampholders will be connected to the same fixture or circuit conductor or terminal. For polarity identification of conductors to screw-shells of lampholders, see Section 200-8.

F. Construction of Fixtures

410-28. Combustible Shades and Enclosures. Adequate air space shall be provided between lamps and shades or other enclosures of combustible material.

410-29. Fixture Rating.

(a) All fixtures requiring ballasts or transformers shall be plainly marked with their electrical rating and the manufacturer's name, trademark or other suitable means of identification.

(b) The electrical rating shall include the voltage and frequency, and shall indicate the current rating of the unit including the ballast, transformer or auto-transformer.

410-30. Design and Material. Fixtures shall be constructed of metal, wood, or other approved material and shall be so designed and assembled as to secure requisite mechanical strength and rigidity. Wireways, including the entrances thereto, shall be such that conductors may be drawn in and withdrawn without injury.

410-31. Nonmetallic Fixtures. In all fixtures not made entirely of metal, wireways shall be lined with metal unless approved armored or lead-covered conductors with suitable fittings are used.

410-32. Mechanical Strength.

(a) Tubing used for arms and stems where provided with cut threads shall be not less than 0.040 inch in thickness and when provided with rolled (pressed) threads shall be not less than 0.025 inch in thickness. Arms and other parts shall be fastened to prevent turning.

(b) Metal canopies supporting lampholders, shades, etc., exceeding 8 lbs., or incorporating attachment plug receptacles, shall be not less than 0.020 inch in thickness. Other canopies shall be not less than 0.016 inch when made of steel and not less than 0.020 inch when of other metals.

(c) Pull type canopy switches shall not be inserted in the rims of metal canopies which are less than 0.025 inch in thickness unless the rims are reinforced by the turning of a bead or the equivalent. Pull type canopy switches, whether mounted in the rims or elsewhere in sheet metal canopies, shall be located not more than 3½ inches from the center of the canopy. Double set screws, double canopy rings, a screw ring, or equal method shall be used where the canopy supports a pull type switch or pendant receptacle.

The above thickness requirements apply to measurements made on finished (formed) canopies.

410-33. Wiring Space. Bodies of fixtures, including portable lamps, shall provide ample space for splices and taps and for the installation of devices, if any. Splice compartments shall be of nonabsorptive, noncombustible material.

410-34. Fixture Studs. Fixture studs which are not parts of outlet boxes, hickeys, tripods, and crowfeet shall be made of steel, malleable iron, or other approved material.

410-35. Insulating Joints. Insulating joints shall be composed of materials especially approved for the purpose. Those which are not designed to be mounted with screws or bolts shall have a substantial exterior metal casing, insulated from both screw connections.

410-36. Portable Lamps. Portable table and floor lamps and fan motors on ceiling fixtures may be wired with approved rubber-covered conductors, provided the wiring is not located so as to be subject to undue heating from lamps.

410-37. Portable Handlamps. Handlamps of the portable type supplied through flexible cords shall be of the molded composition or other type approved for the purpose. Metal-shell paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle. Where subject to physical damage or where lamps may come in contact with combustible material, handlamps shall be equipped with a substantial guard attached to the lampholder or the handle.

For garages, see Section 511-6.

410-38. Cord Bushings. A bushing or the equivalent shall be provided where flexible cord enters the base or stem of a portable lamp. The bushing shall be of insulating material unless a jacketed type of cord is used.

410-39. Tests. All wiring shall be free from short-circuits and grounds, and shall be tested for these defects prior to being connected to the circuit.

410-40. Live Parts. Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least ½ inch between live parts and the mounting plane of the fixture.

G. Installation of Lampholders

410-41. Screw-Shell Type. Lampholders of the screw-shell type shall be installed for use as lampholders only.

410-42. Double-Pole Switched Lampholders. Where used on unidentified 2-wire circuits tapped from the ungrounded conductors of multiwire circuits, the switching device of lampholders of the switched type shall simultaneously disconnect both conductors of the circuit. See Section 200-5.

410-43. Lampholders in Damp or Wet Locations. Lampholders installed in damp or wet locations shall be of the weatherproof type.

H. Construction of Lampholders

410-44. Insulation. The outer metal shell and the cap shall be lined with insulating material which shall prevent the shell and cap from becoming a part of the circuit. The lining shall not extend beyond the metal shell more than ⅛ inch, but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lampholding device.

410-45. Lead Wires. Lead wires, furnished as a part of weatherproof lampholders and intended to be exposed after installation, shall be of approved, stranded, rubber-covered conductors, not less than No. 14 gage (No. 18 gage for candelabra sockets), and shall be sealed in place or otherwise made raintight.

410-46. Switched Lampholders. Switched lampholders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact. The switching mechanism may also interrupt the electrical connection to the screw shell when connection to the center contact is simultaneously interrupted.

J. Lamps

410-49. Bases, Incandescent Lamps. An incandescent lamp for general use on lighting branch circuits shall not be equipped with a Medium base when rated over 300 watts, nor with a Mogul base when rated over 1,500 watts. Above 1,500 watts, special approved bases or other devices shall be used.

410-50. Enclosures, Mercury-Vapor Lamp Auxiliary Equipment. Resistors or regulators for mercury-vapor lamps shall be enclosed in noncombustible cases and treated as sources of heat.

410-51. Arc Lamps. Arc lamps used in theatres shall conform to Section 520-61, and arc lamps used in projection machines shall conform to Section 540-20. Arc lamps used on constant-current systems shall conform to the general requirements of Article 710.

K. Receptacles, Cord Connectors and Attachment Plugs (Caps)

410-52. Rating and Type.

(a) Receptacles installed for the attachment of portable cords shall be rated at not less than 15 amperes, 125 volts, or 10 amperes, 250 volts, and shall be of a type not suitable for use as lampholders.

(b) Metallic faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but may be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

410-53. Receptacles in Floors. Receptacles located in floors shall be enclosed in floor boxes especially approved for the purpose.

Exception: Where such receptacles are located in elevated floors of show-windows or other locations and when the authority enforcing this Code judges them to be free from physical damage, moisture and dirt, the standard approved type of flush receptacle box may be used.

410-54. Receptacles in Damp or Wet Locations. Receptacles installed in damp or wet locations shall be of the weatherproof type.

410-55. Receptacles and Cord Connectors — Grounding Type. Receptacles and cord connectors which are installed to provide for an equipment grounding connection for cord-connected equipment for a 2-wire power supply from a receptacle rated 15 or 20 amperes at a potential under 300 volts shall have one separate fixed grounding member. The terminal for connection to the grounding member shall be designated by a green-colored finish. The design of receptacles and cord connectors shall be such that the grounding connection shall be made before the current carrying connection.

410-56. Attachment Plugs (Caps) — Grounding Type. An attachment plug (cap) for use with a grounding-type receptacle shall, when for use with a grounding type receptacle as described in Section 410-55, have one separate fixed grounding member which shall be so designed as to prevent it from being capable of touching any current-carrying contact of the receptacle. The terminal connection for this grounding member shall be designated by a green-colored finish. The design of attachment plugs (caps) shall be such that the grounding connection shall be made before the current carrying connection.

Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of a hand-held tool or hand-held appliance may be of the movable self restoring type.

L. Rosettes

410-57. Approved Types.

(a) Fusible rosettes shall not be installed.

(b) Separable rosettes which make possible a change in polarity shall not be used.

410-58. Rosettes in Damp or Wet Locations. Rosettes installed in damp or wet locations shall be of the weatherproof type.

410-59. Rating. Rosettes shall be rated at 660 watts, 250 volts, with a maximum current rating of 6 amperes.

410-60. Rosettes for Exposed Wiring. When designed for use with exposed wiring, rosettes shall be provided with bases which shall have at least two holes for supporting screws, shall be high enough to keep the wires and terminals at least ½ inch from the surface wired over, and shall have a porcelain lug under each terminal to prevent the rosette being placed over projections which would reduce the separation to less than ½ inch.

410-61. Rosettes for Use with Boxes or Raceways. When designed for use with conduit boxes or wire raceways, rosette bases shall be high enough to keep wires and terminals at least ⅜ inch from the surface wired over.

M. Special Provisions for Flush and Recessed Fixtures

410-62. Approved Type. Fixtures which are installed in recessed cavities in walls or ceilings shall be of an approved type and shall conform to Sections 410-63 to 410-70 inclusive.

410-63. Temperature.

(a) Fixtures shall be so constructed or installed that adjacent combustible material will not be subjected to temperatures in excess of 90°C (194°F).

(b) Where a fixture is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90°C (194°F), but not higher than 150°C (320°F) is acceptable if the fixture is plainly marked that it is approved for that service.

410-64. Clearance. Recessed portions of enclosures, other than at points of support, shall be spaced at least ½ inch from combustible material.

410-65. Wiring.

(a) Conductors having insulation suitable for the temperature encountered shall be used.

(b) Fixtures having branch circuit terminal connections which operate at temperatures higher than 60°C (140°F) shall have circuit conductors as described in Sections 410-65(b-1 and b-2):

(1) Branch circuit conductors having an insulation suitable for the temperature encountered may be run directly to the fixture.

(2) Tap connection conductors having an insulation suitable for the temperature encountered shall be run from the fixture terminal connection to an outlet box placed at least one foot from the fixture. Such a tap shall extend for at least four feet but not more than six feet and shall be in a suitable metal raceway.

N. Construction, Flush and Recessed Fixtures

410-66. Temperature. Fixtures shall be so constructed that adjacent combustible material will not be subject to temperatures in excess of 90°C (194°F).

410-67. Enclosure. Sheet metal enclosures shall be protected against corrosion by galvanizing, plating, or other equivalent heat-resisting coating, and shall not be less than No. 22 USS gage.

410-68. Lamp Wattage Marking. Incandescent lamp fixtures shall be marked to indicate the maximum allowable wattage of lamps. The markings shall be permanently installed, in letters at least ¼ inch high, and located where visible during relamping.

410-69. Solder Prohibited. No solder shall be used in the construction of the fixture box.

410-70. Lampholders. Lampholders of the screw-shell type shall be of porcelain unless specially approved for the purpose. Cements, where used, shall be of the high-heat type.

P. Special Provisions for Electric Discharge Lighting

Systems of 1,000 Volts or Less

410-71. General.

(a) Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of 1,000 volts or less shall be of a type approved for such service.

(b) The terminals of an electric discharge lamp shall be considered as alive where any lamp terminal is connected to a potential of more than 300 volts.

(c) Transformers of the oil-filled type shall not be used.

(d) In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Part P of this Article.

(e) Fluorescent fixtures for indoor installations shall have an approved thermally actuated protective device integral with the ballast. Such thermal unit shall be installed so as to interrupt the line current on the supply side of both the primary and secondary windings of the ballast. Under no condition shall the thermal device permit the case temperature of the ballast to exceed 120° C. (230° F.). Simple reactance type ballast need not be thermally protected.

This requirement shall become effective January 1, 1967.

410-72. Direct-Current Equipment. Fixtures installed on direct-current circuits shall be equipped with auxiliary equipment and resistors especially designed and approved for direct-current operation and the fixtures shall be so marked.

410-73. Voltages—Dwelling Occupancies.

(a) Equipment having an open-circuit voltage of more than 1000 volts shall not be installed in dwelling occupancies.

(b) Equipment having an open-circuit voltage of more than 300 volts shall not be installed in dwelling occupancies unless such equipment is so designed that there shall be no exposed live parts when lamps are being inserted, are in place, or are being removed.

410-74. Fixture Mounting.

(a) Exposed Ballasts. Fixtures having exposed ballasts or transformers shall be so installed that such ballasts or tranformers shall not be in contact with combustible material.

(b) Combustible Low-Density Cellulose Fiberboard. Where a fixture containing a ballast is to be installed on combustible low-density cellulose fiberboard it shall, where surface mounted:

(1) Be approved for this condition, or

(2) Be spaced not less than 1½ inches from the surface of the fiberboard.

(3) Where such fixtures are partially or wholly recessed, the provisions of Sections 410-62 to 410-70 shall apply.

Combustible low-density cellulose fiberboard is considered to include sheets, panels and tiles which have a density of 20 pounds per cubic foot or less, and which are formed of bonded plant fiber material; but does not include solid or laminated wood, nor fiberboard which has a density in excess of 20 pounds per cubic foot or is an approved material which has been integrally treated with fire retarding chemicals to the degree that the flame spread in any plane of the material will not exceed twenty-five as determined by the method of NFPA No. 255, ASTM Designation E-84 or U.L. No. 723.

410-75. Auxiliary Equipment Not Integral with Fixture.

(a) Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a lighting fixture assembly shall be enclosed in accessible, permanently installed metal cabinets.

(b) Where display cases are not permanently installed, no portion of a secondary circuit may be included in more than a single case.

(c) Ballasts approved for separate mounting and for direct connection to an approved wiring system need not be separately enclosed.

410-76. Auto-Transformers. An auto-transformer which is used as part of a ballast for supplying lighting units and which raises the voltage to more than 300 volts shall be supplied only by a grounded system.

410-77. Switches. Snap switches shall conform to Section 380-14.

Q. Special Provisions for Electric Discharge Lighting Systems of More Than 1,000 Volts

410-78. General.

(a) Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of more than 1,000 volts shall be of a type approved for such service.

(b) The terminal of an electric discharge lamp shall be considered as alive when any lamp terminal is connected to a potential of more than 300 volts.

(c) In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Sections 410-78 to 410-90 inclusive.

For signs and outline lighting, see Article 600.

410-79. Control.

(a) Fixtures or lamp installations shall be controlled either singly or in groups by an externally-operable switch or circuit breaker which shall open all ungrounded primary conductors.

(b) The switch or circuit breaker shall be located within sight of the fixtures or lamps, or it may be located elsewhere if it is provided with means for locking in the open position.

410-80. Lamp Terminals and Lampholders. Parts which must be removed for lamp replacement shall be hinged or fastened by an approved means. Lamps or lampholders or both shall be so designed that there shall be no exposed live parts when lamps are being inserted or are being removed.

410-81. Transformer Ratings. Transformers and ballasts shall have a secondary open-circuit voltage of not more than 15,000 volts with an allowance on test of 1,000 volts additional. The secondary current rating shall be not more than 120 milli-amperes when the open circuit voltage is more than 7500 volts, and not more than 240 milli-amperes when the open circuit voltage is 7500 volts or less.

410-82. Transformer Type. Transformers shall be of an approved enclosed type. Transformers of other than the askarel insulated or dry type shall not be used.

410-83. Transformer Secondary Connections.

(a) The high-voltage windings of transformers shall not be connected in series or in parallel, except that for two transformers, each having one end of its high-voltage winding grounded and connected to the enclosure, the high-voltage windings may be connected in series to form the equivalent of a mid-point grounded transformer.

(b) The grounded ends shall be connected by an insulated conductor not smaller than No. 14 AWG.

410-84. Transformer Locations.

(a) Transformers shall be accessible after installation.

(b) The transformers should be installed as near to the lamps as practicable to keep the secondary conductors as short as possible.

(c) Transformers shall be so located that adjacent combustible materials will not be subjected to temperatures in excess of 90° C (194° F).

410-85. Transformer Loading. The lamps connected to any transformer shall be of such length and characteristics as not to cause a condition of continuous over-voltage on the transformer.

410-86. Wiring Method. Secondary Conductors. Approved gas-tube sign cable suitable for the voltage of the circuit shall be used. For installation of conductors, see Section 600-31.

410-87. Lamp Supports. Lamps shall be adequately supported as required in Section 600-33.

410-88. Exposure to Damage. Lamps shall not be located where normally exposed to physical damage.

410-89. Marking. Each fixture or each secondary circuit of tubing having an open-circuit voltage of more than 1,000 volts shall have a clearly legible marking in letters not less than ¼ inch high reading "Caution . . . . volts." The voltage indicated shall be the rated open-circuit voltage.

410-90. Switches. Snap switches shall conform to Section 380-14.

R. Grounding

410-91. General. Fixtures and lighting equipment shall be grounded as provided in Sections 410-92 to 410-96 inclusive.

410-92. Metallic Wiring Systems. Metal fixtures installed on outlets wired with grounded metal raceway or grounded Type AC metal-clad cable shall be grounded.

410-93. Nonmetallic Wiring Systems. Metal fixtures installed on outlets wired with knob-and-tube work, or nonmetallic sheathed cable, on circuits operating at 150 volts or less to ground, shall be grounded.

Exception No. 1. Fixtures mounted on metal or metal lath ceilings or walls may be insulated from their supports and from the metal lath by the use of insulating joints or fixture supports and canopy insulators. See Section 410-95.

Exception No. 2. Fixtures not mounted on metal or metal lath ceilings or walls need not be insulated or grounded. See Section 410-95.

Fixtures made of insulating materials, and lampholders with shells of insulating material, shall be used with wiring systems that do not afford a ready means for grounding the exposed noncurrent-carrying parts of fixtures and lampholders.

410-94. Equipment of More Than 150 Volts to Ground.

(a) Metal fixtures, transformers and transformer enclosures on circuits operating at more than 150 volts to ground shall be grounded.

(b) Other exposed metal parts shall be grounded unless they are insulated from ground and other conducting surfaces and are inaccessible to unqualified persons, except that lamp tie wires, mounting screws, clips and decorative bands on glass lamps spaced not less than 1½ inches from lamp terminals need not be grounded.

410-95. Equipment Near Grounded Surfaces.

(a) Ungrounded metal lighting fixtures, lampholders and face plates shall not be installed in contact with conducting surfaces nor within 8 feet vertically or 5 feet horizontally of laundry tubs, bath tubs, shower baths, plumbing fixtures, steam pipes or other grounded metal work or grounded surfaces.

(b) Metal pull chains used at these locations shall be provided with insulating links.

410-96. Methods of Grounding. Equipment shall be considered as grounded where mechanically connected in a permanent and effective manner to metal raceway, the armor of Type AC metal-clad cable, the grounding conductor in nonmetallic sheathed cable, or to a separate grounding conductor not smaller than No. 14, provided that the raceway, armor, or grounding conductor is grounded in a manner specified in Article 250.

ARTICLE 422—APPLIANCES

A. General

422-1. Scope. This Article shall apply to electric appliances used in any occupancy.

422-2. Branch Circuit Requirements. Every appliance shall be supplied by a branch circuit of one of the types specified in Article 210. Motor-operated appliances shall also conform to the requirements of Article 430.

See Table 220-5 for the conductors of a household range branch circuit.

B. Installation of Appliances

422-3. Flexible Cords. Flexible cords used to connect heating appliances shall comply with the following:

(a) Heater Cords Required. All smoothing irons and portable electrically heated appliances rated at more than 50 watts and which produce temperatures in excess of 121°C (250°F) on surfaces with which the cord is liable to be in contact shall be provided with one of the types of approved heater cords listed in Table 400-11.

(b) Other Heating Appliances. All other portable electrically heated appliances shall be connected with one of the approved types of cord listed in Table 400-11, selected in accordance with the usage specified in that Table.

422-4. Insulation of Appliances. Portable appliances shall be provided with an adequate dielectric interposed between current-carrying parts and those external surfaces which persons can touch, except for toasters, grills or other heating appliances in which the current-carrying parts at high temperature are necessarily exposed. In locations where the dielectric is exposed to physical damage, it shall be suitably protected.

422-5. Portable Immersion Heaters. Electric heaters of the portable immersion type shall be so constructed and installed that current-carrying parts are effectively insulated from electrical contact with the substance in which immersed. The authority enforcing this Code may make exception of special applications of apparatus where suitable precautionary measures are followed.

422-6. Protection of Combustible Material. Each electrically heated appliance that is obviously intended by size, weight and service to be located in a fixed position shall be so placed as to provide ample protection between the appliance and adjacent combustible material.

422-7. Stands for Portable Appliances. Each smoothing iron and other portable electrically heated appliance which is intended to be applied to combustible material shall be equipped with an approved stand, which may be a separate piece of equipment or may be a part of the appliance.

422-8. Signals for Heated Appliances. In other than residence occupancies, each electrically heated appliance, or group of electrically heated appliances, intended to be applied to combustible material, shall be installed in connection with a signal unless the appliance is provided with an integral temperature-limiting device.

422-9. Flatirons. Electrically heated smoothing irons intended for use in residences shall be equipped with approved temperature-limiting means.

422-10. Water Heaters. Each water heater shall be equipped with temperature limiting means in addition to the control thermostats to disconnect all ungrounded conductors and such means shall be:

(1) installed to sense maximum water temperature.

(2) trip-free manually reset or it shall use a replacement element.

(3) in addition to any other devices protecting the tank against excessive temperature or pressure or both.

422-11. Infrared Lamp Industrial Heating Appliances.

(a) Infrared heating lamps rated at 300 watts or less may be used with lampholders of the medium-base unswitched porcelain type, or other types approved for the purpose.

(b) Screw-shell lampholders shall not be used with infrared lamps over 300 watts rating unless the lampholders are especially approved for the purpose.

(c) Lampholders may be connected to any of the branch circuits of Article 210 and, in industrial occupancies, may be operated in series on circuits of more than 150 volts to ground provided the voltage rating of the lampholders is not less than the circuit voltage.

Each section, panel or strip carrying a number of infrared lampholders (including the internal wiring of such section, panel or strip) is considered an appliance. The terminal connection block of each such assembly is deemed an individual outlet.

422-12. Grounding. Metal frames of portable and stationary electrically heated appliances, operating on circuits above 150 volts to ground, shall be grounded in the manner specified in Article 250; provided, however, that where this is impracticable, grounding may be omitted by special permission, in which case the frames shall be permanently and effectively insulated from the ground.

Frames shall be grounded in all cases. For methods of grounding frames of electric ranges and clothes dryers, see Sections 250-57 and 250-60.

422-13. Wall-Mounted Ovens and Counter-Mounted Cooking Units.

(a) Wall-mounted ovens and counter-mounted cooking units complete with provisions for mounting and for making electrical connections shall be considered as fixed appliances.

(b) A separable connector or a plug and receptacle combination in the supply line to an oven or cooking unit used only for ease in servicing or for installation shall:

(1) Not be installed as the disconnecting means required by Section 422-20;

(2) Be approved for the temperature of the space in which it is located.

C. Control and Protection of Appliances

422-20. Disconnecting Means. Each appliance shall be provided with a means for disconnection from all ungrounded conductors.

422-21. Disconnection of Fixed Appliances.

(a) For fixed appliances rated at not over 300 volt amperes or ⅛ hp. the branch circuit overcurrent device may serve as the disconnection means.

(b) For fixed appliances of greater rating the branch circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.

422-22. Disconnection of Portable Appliances.

(a) For portable appliances a separable connector or an attachment plug and receptacle may serve as the disconnecting means.

(b) The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto, except that demand factors authorized elsewhere in this Code may be applied.

(c) Attachment plugs and connectors shall conform to the following:

(1) Live Parts. They shall be so constructed and installed as to guard against inadvertent contact with live parts.

(2) Interrupting Capacity. They shall be capable of interrupting their rated current without hazard to the operator.

(3) Interchangeability. They shall be so designed that they will not fit into receptacles of lesser rating.

422-23. Disconnection of Stationary Appliances.

(a) For stationary appliances rated at not over 300 volt amperes or ⅛ horsepower, the branch-circuit overcurrent device may serve as the disconnecting means.

(b) For stationary appliances of greater rating the branch-circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.

(c) For cord-connected appliances, such as household ranges and clothes dryers, a separable connector or an attachment plug and receptacle may serve as the disconnecting means.

For household electric ranges, a plug and receptacle connection at the rear base of a range, if it is accessible from the front by removal of a drawer, is considered as meeting the intent of this rule.

422-24. Unit Switches as Disconnecting Means. Unit switches which are a part of an appliance shall not be considered as taking the place of the single disconnecting means required by Part C of this Article, unless there are other means for disconnection as follows:

(a) Multi-Family Dwellings. In multi-family (more than two) dwellings, the disconnecting means shall be within the apartment, or on the same floor as the apartment in which the appliance is installed, and may control lamps and other appliances.

(b) Two-Family Dwellings. In two-family dwellings, the disconnecting means may be outside of the apartment in which the appliance is installed. This will permit an individual switch for the apartment to be used.

(c) Single-Family Dwellings. In single-family dwellings, the service disconnecting means may be used.

(d) Other Occupancies. In other occupancies, the branch-circuit switch or circuit breaker, where readily accessible to the user of the appliance, may be used for this purpose.

422-25. Switch and Circuit Breaker to Be Indicating. Switches and circuit breakers used as disconnecting means shall be of the indicating type.

422-26. Motor-Driven Appliances. A switch or circuit breaker which serves as the disconnecting means for a stationary motor-driven appliance of more than ⅛ horsepower shall be located within sight of the motor controller or shall be capable of being locked in the open position.

422-27. Overcurrent Protection.

(a) Appliances, other than such motor-operated appliances as are required by Article 430 to have additional overcurrent protection, shall be considered as protected against overcurrent when supplied by one of the circuits of Article 210 and in accordance with the requirements therein specified.

(b) A household type appliance with surface heating elements and which has a maximum demand of more than 60 amperes as calculated in accordance with Table 220-5 shall have its power supply subdivided into two or more circuits each of which is provided with overcurrent protection rated at not more than 50 amperes.

(c) Infrared lamp heating appliances shall have overcurrent protection not exceeding 50 amperes.

(d) Open coil or exposed sheathed-coil types of surface heating elements in commercial type heating appliances shall be protected by overcurrent protection devices which are rated at not more than 50 amperes.

(e) A duct heater exceeding a 40 ampere rating shall have the heating elements subdivided and each such subdivision shall be protected by overcurrent protection devices which are rated at not more than 50 amperes.

D. Marking of Appliances

422-30. Nameplate. Each electric appliance shall be provided with a nameplate, giving the maker's name and the normal rating in volts and amperes, or in volts and watts.

422-31. Marking of Heating Elements. Individual heating elements which are a part of an electric appliance containing more than one heating element shall each be legibly marked with normal rating in volts and amperes, or in volts and watts.

422-32. Appliance Consisting of Motors and Other Loads. The marking on an appliance shall specify the rating of the motor in volts and amperes, and the additional load (heaters, lights, etc.) in volts and watts or amperes.

Exception No. 1 — Portable Appliances.

Exception No. 2 — Fixed or stationary appliances employing a motor 1/20 hp or less.

E. Special Provisions For Fixed Indoor Electrical Space Heating

422-40. General.

(a) Equipment for use with electrical space heating systems shall be of a type approved for such service.

(b) In addition to complying with the general requirements for appliances, such equipment shall comply with Part E of this Article.

(c) The special provisions of this Article shall apply to electrically energized units, panels and cables for space heating. They shall also include central heating systems employing electrical heating units.

(d) Electrical space heating systems employing methods of installation other than covered by Part E of this Article may be used only by special permission.

422-41. Use. Space heating systems shall not be used:

(a) Where exposed to severe physical damage unless adequately protected.

(b) In wet or damp locations unless specially approved for the purpose.

See also rules on Corrosive Conditions, Section 310-7.

422-42. Temperature Limitations. The operating temperature of room surfaces where embedded elements and panels are used shall not exceed 66°C. (150°F.). (Based on room temperature of 30°C., 86°F.)

422-43. Appliances to Be Complete Units.

(a) Panels and cables shall be installed in their complete sizes or lengths as supplied by the manufacturer.

(b) Units which are shortened or from which the marking labels or nameplates are missing shall not be installed.

(c) Units shall be suitable for use with approved wiring systems.

422-44. Heating Cable Construction. Heating cables shall be furnished complete with factory-assembled nonheating leads at least 7 feet in length, and the leads shall consist of conductors and wiring approved for general use or other wiring approved for the purpose.

422-45. Marking of Heating Cables. Each unit length of heating cable shall have a permanent marking located within 3 inches of the terminal end of the nonheating leads, and shall be legibly marked with the manufacturer's name or identification symbol, catalog number, and rating in volts and watts or amperes.

The lead wires shall have the following color identifications: 230 volts nominal—red, 115 volts nominal—yellow.

422-46. Controllers and Disconnecting Means.

(a) Thermostats and thermostatically controlled switching devices which indicate an "off" position and which interrupt line current shall open all ungrounded conductors in the "off" position.

(b) Thermostats and thermostatically controlled switching devices which do not have "on" or "off" positions are not required to open all ungrounded conductors.

See Sections 422-20, 422-23 and 422-24 for disconnecting means for stationary appliances.

(c) Switching devices consisting of combined thermostats and manually controlled switches which serve both as controllers and disconnecting means shall:

(1) Open regardless of temperature all ungrounded conductors when manually placed in the "off" position;

(2) Be so designed that the circuit cannot be energized automatically after the device has been manually placed in the "off" position.

422-47. Clearances of Wiring in Ceilings.

(a) Wiring located above heated ceilings and within thermal insulation shall be spaced not less than 2 inches above the heated ceiling and shall be considered as operating at an ambient of 50°C. The ampacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

(b) Wiring located above heated ceilings and over thermal insulation having a minimum thickness of 2 inches requires no correction for temperature.

(c) Wiring located above heated ceilings and within a joist space having no thermal insulation shall be spaced not less than two inches above the ceiling and shall be considered as operating at an ambient of 50°C. The ampacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

422-48. Clearances of Wiring in Walls.

(a) Where located in exterior walls, wiring shall be located outside the thermal insulation.

(b) Where located in interior walls or partitions, wiring shall be located away from the heated surfaces, and the wiring shall be considered as operating at an ambient of 40°C. (104°F.); and the ampacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

422-49. Area Restrictions.

(a) Heating panels shall not extend beyond the room in which they originate.

(b) Cables shall not be installed in closets, over cabinets which extend to the ceiling, under walls or partitions or over walls or partitions which extend to the ceiling.

Exception: Single runs of cable may pass over partitions where they are embedded.

(c) This requirement shall not prohibit low-temperature heat sources in closets to control relative humidity.

422-50. Clearance from Other Objects and Openings. Panels and cables shall be separated at least 8 inches from lighting fixtures, outlet and junction boxes, and 2 inches from ventilating openings and other such openings in room surfaces, or sufficient area shall be provided to assure that no heating cables or panels will be covered by surface mounted lighting units.

422-51. Splices. Embedded cables may be spliced only where necessary and only by approved means, and in no case shall the length of the heating cable be altered.

422-52. Installation of Heating Cables in Dry Board and Plaster.

(a) Cables shall not be installed in walls.

(b) Adjacent runs of cable not exceeding 2¾ watts per foot shall be installed not less than 1½ inches on centers.

(c) Heating cables may be applied only to gypsum board, plaster lath and similar fire-resistant materials. With metal lath or other conducting surfaces, a coat of plaster (brown or scratch coat) shall be applied to completely cover the metal lath or conducting surface before the cable is attached.

(d) The entire ceiling surface shall have a finish of thermally noninsulating sand plaster or other approved noninsulating material having a nominal thickness of ½-inch.

(e) Cables shall be secured at intervals not exceeding 16 inches by means of approved stapling, tape, plaster or other approved means. Staples or metal fasteners which straddle the cable shall not be used with metal lath or other conducting surface.

(f) In dry board installations, after the heating cable is installed, the entire ceiling below it shall be covered with gypsum board not exceeding ½-inch thickness. The void between the upper layer of gypsum board and the surface layer of gypsum board shall be filled with thermally conducting plaster or other approved material.

(g) Cables shall be kept free from contact with metal or conducting surfaces.

(h) Caution should be used in attaching a surface layer of gypsum so that the nails or other fastenings do not pierce the heating cable.

422-53. Installation of Nonheating Leads.

(a) Nonheating leads of cables shall be installed in accordance with approved wiring methods from the junction box to a location on the underside of the ceiling.

(b) Excess leads shall not be cut but shall be secured to the underside of the ceiling and embedded in plaster or other approved material, leaving only a length sufficient to reach the junction box with not less than 6 inches of free lead within the box.

(c) The marking of the leads shall be visible in the junction box.

422-54. Installation of Cables in Concrete or Poured Masonry Floors.

(a) Adjacent runs of cable not exceeding 2¾ watts per foot shall be installed not less than 1 inch on centers.

(b) Cables shall be secured in place by nonmetallic frames or spreaders or other approved means while the concrete or other finish is applied.

(c) A spacing of at least 1 inch shall be maintained between the heating cable and other metallic bodies embedded in the floor.

(d) Leads shall be protected where they leave the floor by rigid metal conduit, electrical metallic tubing, or by other approved raceways extending to the junction box.

(e) Bushings shall be used where the leads emerge in the floor slab.

422-55. Tests During and After Installation.

(a) Embedded cable installations shall be made with due care to prevent damage to the cable assembly and shall be inspected and approved before cables are covered or concealed.

(b) Cable shall be tested for insulation resistance after plastering or the pouring of floors. See Section 110-20, Insulation Resistance.

422-56. Installation of Resistance Heaters in Air Ducts.

(a) A heater which is to be installed in an air duct or plenum shall be approved for the purpose and shall be installed in the manner approved for the equipment.

(b) Each duct heater shall be provided with an approved temperature limiting control to de-energize the circuit.

(c) In addition a supplementary independent control shall also be provided in each duct heater to prevent overheating. This device shall be manually resettable or replaceable.

(d) Duct and plenum heater controller equipment shall be accessible with the disconnecting means installed at or within sight of the controller.

(e) Where a duct heater is supplied by more than one source of supply, the disconnecting means serving the duct heater shall be grouped and identified.

F. Provisions for Room Air-Conditioning Units

422-60. General. The provisions of Sections 422-61 to 63 inclusive shall apply to electrically energized units and equipment which control temperature and humidity.

See Section 422-56.

422-61. Grounding. Exposed noncurrent-carrying metal parts which are liable to become energized shall be grounded under one or more of the following conditions:

(a) Where permanently connected to metal-enclosed wiring;

(b) When in a wet location and not isolated;

(c) When within reach of a person standing on the ground outside of a building;

(d) When in a hazardous location, see Article 500;

(e) Where in electrical contact with metal or metal lath;

(f) Where more than 150 volts to ground.

422-62. Branch Circuit Requirements.

(a) The total load of motor operated air-conditioning equipment shall not exceed 80 per cent of the rating of a branch circuit which does not supply lighting units or other appliances.

(b) The total load of air-conditioning equipment shall not exceed 50 per cent of the rating of a branch circuit where lighting units or other appliances are also supplied.

(c) For air-conditioning units employing two or more motors, see Section 430-53(d).

422-63. Disconnecting Means. A separable connector or an attachment plug and receptacle may serve as the disconnecting means.

G. Special Provisions for Fixed Outdoor Electric Deicing and Snow Melting Installations

422-70. General.

(a) Equipment for use with electric deicing and snow melting systems shall be of a type approved for such service.

(b) In addition to complying with the general requirements for appliances, such equipment shall comply with Part G of this Article.

(c) The special provisions of this Article shall apply to electrically energized heating units, panels, and cables, embedded in poured masonry or asphalt driveways, walks, steps, and other areas.

(d) Electrical heating systems employing methods of construction or installation other than covered by Part G of this Article may be used only by special permission.

422-71. Use.

(a) Deicing and snow melting equipment may be installed only in the specific materials for which they are approved.

(b) Deicing and snow melting units shall not be used where exposed to severe physical damage, unless adequately protected.

422-72. Appliances To Be Complete Units.

(a) Units, panels, and cables shall be installed in their complete sizes or lengths as supplied by the manufacturer.

Exception: by special permission of the authority enforcing the Code.

(b) Units which are shortened, or from which the marking nameplates are missing shall not be installed except that the non-heating lead may be shortened if the marking specified in Section 422-76 is retained.

(c) Units shall be suitable for use with approved wiring systems.

422-73. Non-Heating Leads. Non-heating leads on the cables, panels, or units shall be furnished as part of the factory assembly. The leads shall consist of conductors and wiring approved for general use, or other wiring approved for the purpose.

422-74. Installation Of Heating Cables, Units, Or Panels.

(a) The operating characteristics of embedded assemblies of heating equipment depend upon the specific materials involved and therefore embedded equipment should be installed as designed for use in such materials.

(b) Panels or heating units shall not exceed 120 watts per square foot of heated area.

(c) The spacing between adjacent cable runs is dependent upon the rating of the cable, but may in no case be less than 1 inch on centers.

(d) Units, panels and cables shall be installed either:

(1) On a substantial asphalt or masonry base at least 2 inches thick and have at least 1½ inches of asphalt or masonry applied over the units, panels or cables, or

(2) they may be installed over other approved bases and embedded within 3½ inches of masonry or asphalt but not less than one inch from the top surface.

(e) Cables shall be secured in place by frames or spreaders, or other approved means, while the masonry or asphalt finish is applied.

(f) Cables, units and panels shall not be installed where they bridge expansion joints unless adequately protected from expansion and contraction.

422-75. Installation Of Non-Heating Leads.

(a) Non-heating leads having a grounding sheath or braid may be embedded in masonry or asphalt similar to the heating cable without additional protection.

(b) Non-heating leads of type TW and other approved types not having a grounding sheath shall be enclosed in conduit, electrical metallic tubing or other raceways within the asphalt or masonry and the distance from the factory splice to the raceway shall be not less than 1 inch nor more than 6 inches.

(c) Bushings shall be used in the asphalt or masonry where leads enter conduit, tubing or raceway.

(d) Leads shall be protected in expansion joints and where they emerge from masonry or asphalt by conduit, electrical metallic tubing or other raceways.

(e) Not less than 6 inches of non-heating lead shall be within the junction box.

422-76. Marking. Each heating unit, panel and cable shall be legibly marked within 3 inches of the termination of the non-heating lead with the identification symbol, catalog number, and rating in volts and watts or amperes.

422-77. Junction Boxes. All splices other than factory splices shall be made in properly installed boxes approved for the location.

422-78. Grounding.

(a) Grounding means such as copper braid, lead or copper sheath, or other approved means shall be provided as part of the heating section of the approved cable, panel or unit.

(b) All non-current-carrying parts which are liable to become energized shall be bonded together and positively connected to a continuous (unbroken) No. 14 AWG or larger covered copper wire extending to the distribution panelboard. Where the bonding conductor is subject to physical damage it shall be at least No. 10 AWG copper.

422-79. Tests. Embedded heating installation shall be inspected and approved before being covered.

ARTICLE 430 — MOTORS, MOTOR CIRCUITS AND CONTROLLERS

A. General

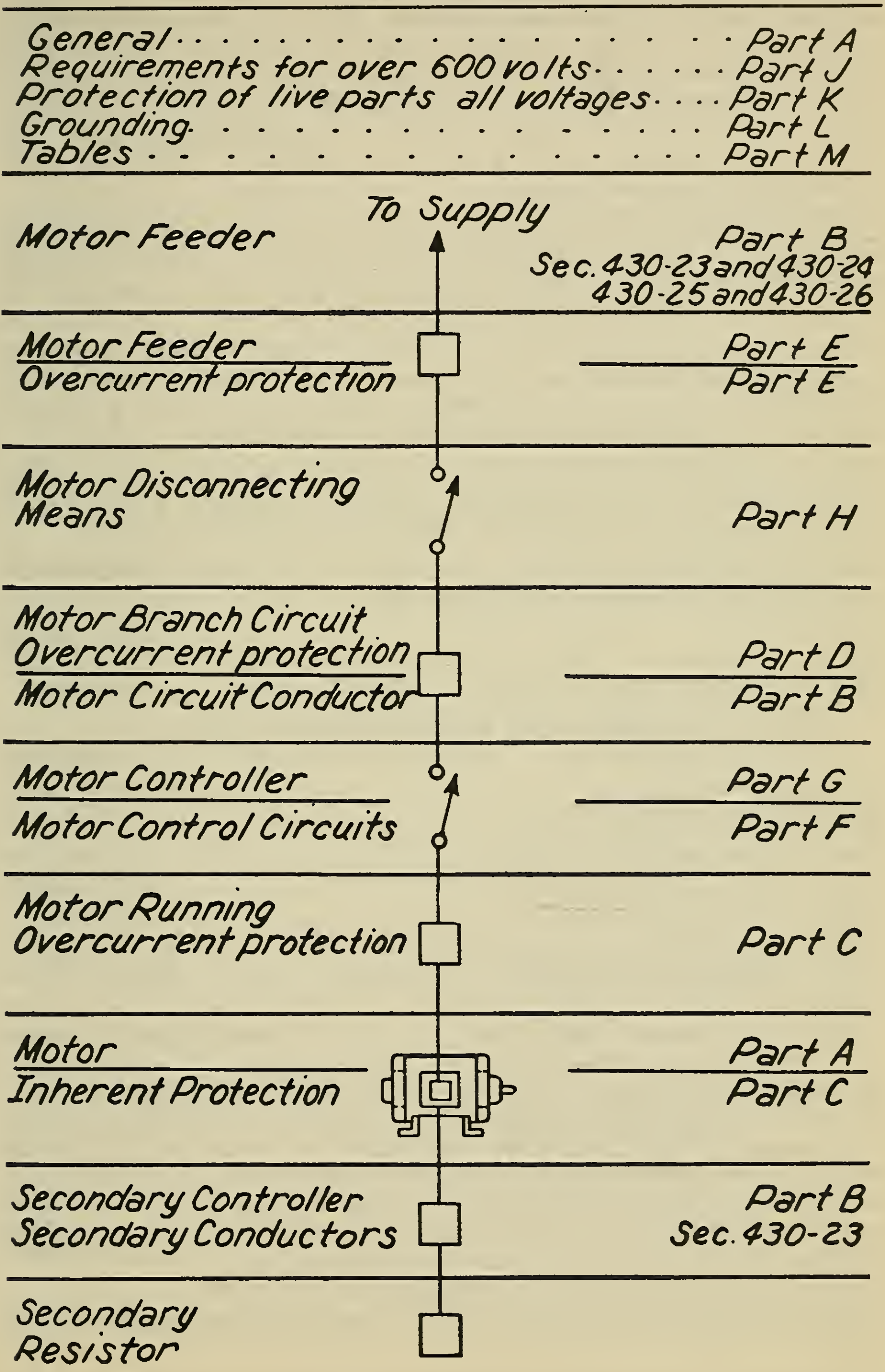
430-1. (a). Motor Feeder and Branch Circuits. (See Diagram 430-1(a).

(b) General. The following general requirements cover provisions for motors, motor circuits, and controllers which do not properly fall into the other parts of this Article.

430-2. Sealed (Hermetic Type) Refrigeration Compressor. For the purposes of this Article, a sealed (hermetic-type) refrigeration compressor is a mechanical compressor consisting of a compressor and a motor, both of which are enclosed in the same housing, with no external shaft nor shaft seals, the motor operating in the refrigerant atmosphere.

430-3. Part Winding Motors. A part-winding-start induction or synchronous motor is one arranged for starting by first energizing part of

Diagram 430-1(a)


General . . . . Part A
Requirements for over 600 volts . . . . . Part J
Protection of live parts all voltages . . . Part K
Grounding . . . . Part L
Tables . . . . Part M
To Supply
Motor Feeder
Part B
Sec. 430-23 and 430-24
430-25 and 430-26
Motor Feeder
Overcurrent protection
Part E
Part E
Motor Disconnecting Means
Part H
Motor Branch Circuit Overcurrent protection
Motor Circuit Conductor
Part D
Part B
Motor Controller
Motor Control Circuits
Part G
Part F
Motor Running Overcurrent protection
Part C
Motor
Inherent Protection
Part A
Part C
Secondary Controller
Secondary Conductors
Part B
Sec. 430-23
Secondary Resistor

its primary (armature) winding and, subsequently, energizing the remainder of this winding in one or more steps. The purpose is to reduce the initial values of the starting current drawn or the starting torque developed by the motor. A standard part-winding-start induction motor is arranged so that one-half of its primary winding can be energized initially and, subsequently, the remaining half can be energized, both halves then carrying the same current. A sealed "hermetic type" refrigeration compressor motor is not to be considered a standard part-winding-start induction motor.

When separate overcurrent devices are used with a standard part-winding-start induction motor, each half of the motor winding shall be individually protected in accordance with Sections 430-32 and 430-37, except that the trip current shall be one-half that specified.

Each motor winding connection shall have short circuit and ground fault protection rated at not more than one-half that specified by Section 430-52 except that a single device having this half rating may be used for both windings if this will allow the motor to start.

430-4. In Sight From. Where in this Article it is specified that some equipment shall be "in sight from" another equipment, it means that the equipment must be visible and not more than 50 feet distant.

430-5. Other Articles. Motors and controllers shall also comply with the applicable provisions of the following:

Capacitors	Section 460-9
Cranes and Hoists	Article 610
Elevators, Dumbwaiters, Escalators, and Moving Walks	Article 620
Garages, Aircraft Hangars, Gasoline Dispensing and Service Stations, Bulk Storage Plants, Finishing Processes and Flammable Anesthetics	Articles 511, 513, 514, 515, 516, and 517
Hazardous Locations	Articles 500-503
Metalworking Machine Tools	Article 670
Motion-picture Projectors	Sections 540-12, 540-17
Motion-picture Studios	Article 530
Organs	Section 650-3
Resistors and Reactors	Article 470
Theaters	Section 520-48

430-6. Ampacity Determination. Ampacities shall be determined as follows:

(a) General Motor Applications. Except as noted in Section 430-6 (b), whenever the current rating of a motor is used to determine the ampacity of conductors, switches, branch-circuit overcurrent devices, etc., the values given in Tables 430-147, 430-148, 430-149, and 430-150, including notes, shall be used instead of actual current rating marked on the motor nameplate. Motor running overcurrent protection shall be based on the motor nameplate current rating. When a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Tables 430-147, 430-148, 430-149, and 430-150 interpolated if necessary.

Exception: For multispeed motors, see Sections 430-22(a) and 430-52.

(b) Sealed (Hermetic-Type) Refrigeration Compressor Motors. For sealed (hermetic-type) refrigeration compressor motors the full-load current marked on the nameplate for the compressor shall be used to determine the ampacity of the branch-circuit conductors (see Sections 430-22 and 430-24), branch-circuit overcurrent protection, and motor-running overcurrent protection. For motor controllers and disconnecting means, see Section 430-83 Exception No. 3, and Section 430-110.

430-7. Marking on Motors.

(a) Usual Motor Applications. A motor shall be provided with a nameplate showing the maker's name, the rating in volts and amperes, including those of the secondary if a wound-rotor type of motor, the normal full-load speed and the interval during which it can operate at full load starting cold, before reaching its rated temperature. The time interval shall be 5, 15, 30, or 60 minutes, or continuous. A motor rated at ⅛ horsepower or larger shall have the horsepower rating marked on the nameplate except that the motors of arc welders may be marked in amperes. A multispeed motor, except a shaded pole or permanent split-capacitor motor, shall have the amperes and horsepower at each speed marked on the name plate. A motor provided with a protective device integral with the motor, that complies with Section 430-32(a-2) or 430-32(c-2) shall be permanently marked "Thermally Protected." An alternating-current motor rated at ½ horsepower or larger, unless it is a polyphase wound-rotor motor, shall have the nameplate marked with a code letter to show its input in kilovolt-amperes with locked rotor, selected from Table 430-7(b). Motors complying with Section 430-32(c) (4) shall be marked "Impedance-Protected."

(b) Locked Rotor Indicating Code Letters. Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430-7(b).

The code letter indicating motor input with locked rotor must be in an individual block on the nameplate, properly designated. This code letter is to be used for determining branch-circuit overcurrent protection by reference to Table 430-152, as provided in Section 430-52.

(1) Multi-speed motors shall be marked with the code letter designating the locked-rotor KVA per horsepower for the highest speed at which the motor can be started, except constant horsepower motors which shall be marked with the code letter giving the highest locked-rotor KVA per horsepower.

(2) Single-speed motors starting on Y connection and running on delta connections shall be marked with a code letter corresponding to the locked-rotor KVA per horsepower for the Y connection.

(3) Dual-voltage motors which have a different locked-rotor KVA per horsepower on the two voltages shall be marked with the code letter for the voltage giving the highest locked-rotor KVA per horsepower.

(4) Motors with 60- and 50-cycle ratings shall be marked with a code letter designating the locked rotor KVA per horsepower on 60 cycles.

(5) Part-winding-start motors shall be marked with a code letter designating the locked-rotor KVA per horsepower that is based upon the locked-rotor current for the full winding of the motor.

Table 430-7(b). Locked Rotor Indicating Code Letters

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor
A	0 — 3.14
B	3.15 — 3.54
C	3.55 — 3.99
D	4.0 — 4.49
E	4.5 — 4.99
F	5.0 — 5.59
G	5.6 — 6.29
H	6.3 — 7.09
J	7.1 — 7.99
K	8.0 — 8.99
L	9.0 — 9.99
M	10.0 — 11.19
N	11.2 — 12.49
P	12.5 — 13.99
R	14.0 — 15.99
S	16.0 — 17.99
T	18.0 — 19.99
U	20.0 — 22.39
V	22.4 — and up

The above table is an adopted standard of the National Electrical Manufacturers Association.

(c) Sealed (Hermetic-Type) Refrigeration Compressor Motors. Sealed (hermetic-type) refrigeration compressors shall be provided with a nameplate which shall give the manufacturer's name; the phase, voltage, frequency, and the full load current in amperes of the motor (operating current when the compressor is delivering rated output). The locked-rotor current of single-phase motors having full load currents in amperes of more than 9 amperes at 115 volts and more than 4.5 amperes at 230 volts and all polyphase motors shall also be marked on the nameplate. When a protective device integral with a motor is used (see Section 430-32), the nameplate shall be marked with the words "Thermal Protection."

Note: The words "Thermally Protected" are to replace words "Thermal Protection" on the nameplate effective January 1, 1967.

430-8. Marking on Controllers. A controller shall be marked with the maker's name or identification, the voltage, the current or horsepower rating, and such other data as may be needed to properly indicate the motors for which it is suitable.

Where a controller is built in as an integral part of a motor or of a motor-generator set, the controller need not be individually marked when the necessary data is on the motor nameplate.

430-9. Marking at Terminals. Terminals of motors and controllers shall be suitably marked or colored where necessary to indicate the proper connections.

430-10. Wiring Space in Enclosures. Enclosures for controllers and disconnecting means for motors shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to the other apparatus unless designs are employed which provide adequate space for this purpose.

430-11. Protection Against Liquids. Suitable guards or enclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment, or in other locations where dripping or spraying oil, water, or other injurious liquid may occur, unless the motor is designed for the existing conditions.

430-12. Motor Terminal Housings. Motor terminal housings shall be of ample size to properly make connections and shall be of substantial metal construction.

430-13. Bushing. Where wires pass through an opening in an enclosure, conduit box or barrier, a bushing shall be used to protect the conductors from the edges of the openings having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. If used where there may be a presence of oils, greases, or other contaminants, the bushing shall be made of material not deleteriously affected.

For conductors, see Section 310-7.

430-14. Location of Motors.

(a) Ventilation and Maintenance. Motors shall be located so that adequate ventilation is provided and so that maintenance such as lubrication of bearings and replacing of brushes can be readily accomplished.

(b) Open Motors. Open motors having commutators or collector rings shall be located or protected so that sparks cannot reach adjacent combustible material. This does not prohibit the installation of these motors on wooden floors or supports.

430-16. Overheating from Dust Accumulations. In locations where dust or flying material will collect on or in motors in such quantities as to seriously interfere with the ventilation or cooling of motors, and thereby caused dangerous temperatures, suitable types of enclosed motors which will not overheat under the prevailing conditions, shall be used. Especially severe conditions may require the use of enclosed pipe ventilated motors, or enclosure in separate dust-tight rooms, properly ventilated from a source of clean air.

B. Motor Circuit Conductors

430-21. General. The provisions of Part B specify sizes of conductors capable of carrying the motor current without overheating under the conditions specified.

(a) The provisions of Articles 250 and 310 are not intended to apply to conductors which form an integral part of equipment, such as motors, motor controllers, and the like. See Sections 300-1(d) and 310-1(c).

430-22. Single Motor.

(a) Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 per cent of the motor full-load current rating.

In case of a multispeed motor, the selection of branch circuit conductors on the line side of the controller shall be based on the highest of the full load current ratings shown on the motor name plate; selection of branch circuit conductors between the controller and the motor, which are energized for that particular speed, shall be based on the current rating for that speed.

Exception: Conductors for a motor used for short-time, intermittent, periodic, or varying duty shall have an ampacity not less than the percentage of the motor nameplate current rating as shown in Table 430-22 (a-Exception) unless the authority enforcing the Code grants special permission for conductors of smaller size.

(b) The conductors between a stationary motor rated one horsepower or less, and the separate terminal enclosures permitted in Section

Table 430-22 (a-Exception)

Classification of Service	Percentages of Nameplate Current Rating 5-Minute Rated Motor	15-Minute Rated Motor	30 & 60 Minute Rated Motor	Continuous Rated Motor
Short-Time Duty Operating valves, raising or lowering rolls, etc.	110	120	150	...
Intermittent Duty Freight and passenger elevators, tool heads, pumps, drawbridges, turntables, single-operator arc welders for manual welding, etc.	85	85	90*	140
Periodic Duty Rolls, ore and coal-handling machines, etc.	85	90	95	140
Varying Duty	110	120	150	200

*This figure also applies for conductors which supply a motor-generator single-operator arc welder which has a 60 per cent duty cycle rating.

Any motor application is considered to be for continuous duty unless the nature of the apparatus which it drives is such that the motor will not operate continuously with load under any condition of use.

For long runs, it may be necessary in order to avoid excessive voltage drop, to use conductors of sizes larger than the minimum sizes selected from Tables 310-12 to 310-15 inclusive.

See Example No. 8, Ch. 9, and Diagram in Section 430-1.

430-145(b) may be smaller than No. 14 but not smaller than No. 18, provided they have an ampacity as specified above.

430-23. Wound-Rotor Secondary.

(a) For continuous duty the conductors connecting the secondary of a wound-rotor alternating-current motor to its controller shall have an ampacity which is not less than 125 per cent of the full-load secondary current of the motor.

(b) For other than continuous duty, these conductors shall have an ampacity, in per cent of full load secondary current, not less than that specified in Table 430-22 (a-Exception).

(c) Where the secondary resistor is separate from the controller, the ampacity of the conductors between controller and resistor shall be not less than that given in Table 430-23 (c).

Table 430-23 (c)

Resistor Duty Classification	Ampacity of Wire in Per Cent of Full-Load Secondary Current
Light starting duty	35
Heavy starting duty	45
Extra heavy starting duty	55
Light intermittent duty	65
Medium intermittent duty	75
Heavy intermittent duty	85
Continuous duty	110

430-24. Conductors Supplying Several Motors. Conductors supplying two or more motors shall have an ampacity of not less than 125 per cent of the full-load current rating of the highest rated motor in the group plus the sum of the full-load current ratings of the remainder of the motors in the group. Where one or more motors of a group are used on short time, intermittent, periodic, or varying duty, the conductors shall have an ampacity of not less than 125 per cent of the name plate full load current of the highest rated continuous duty motor or the highest current obtained by multiplying the applicable percentage of Table 430-22 (a-Exception), by the name plate full load current of any non-continuous duty motor, whichever is the larger, plus the name plate full load currents of the other motors, each multiplied by 100 per cent or the applicable percentage of the table, whichever is smaller.

Exception: When the circuitry is so interlocked as to prevent the starting and running of a second motor or group of motors, the conductor size shall be determined from the larger motor or group of motors that are to be operated at a given time.

See Example No. 8, Chapter 9.

430-25. Combination Load. Conductors supplying a motor load, and in addition a lighting or appliance load as computed from Article 220 and other applicable Sections, shall have an ampacity sufficient for the lighting or appliance load plus the required capacity for the motor load determined in accordance with Section 430-24, or, for a single motor, in accordance with Section 430-22.

430-26. Feeder Demand-Factor. Where a reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time the authority enforcing this Code may grant permission for feeder conductors to be of a capacity less than specified in the Sections 430-24 and 430-25, provided the conductor is of sufficient ampacity for the maximum load determined by the sizes and number of motors supplied and the character of their loads and duties.

430-27. Capacitors with Motors: For provisions covering conductors where capacitors are installed on motor circuits, see Sections 460-7, 460-8, 460-9.

C. Motor Running Overcurrent (Overload) Protection

430-31. General. The provisions of Part C specify overcurrent devices intended to protect the motors, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overloads.

(a) Overload in electrical apparatus is an operating overcurrent which, when it persists for a sufficient length of time, would cause damage or dangerous overheating of the apparatus. It does not include short circuits or ground faults.

(b) These provisions shall not be interpreted as requiring overcurrent protection where it might introduce additional or increased hazards as in the case of fire pumps [see NFPA Standard for Centrifugal Fire Pumps (No. 20)].

430-32. Continuous Duty Motors.

(a) More Than One Horsepower. Each continuous duty motor rated more than one horsepower shall be protected against running overcurrent by one of the following means:

(1) A separate overcurrent device which is responsive to motor current. This device shall be rated or selected to trip at not more than 125 per cent of the motor full-load current rating for sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40° C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Section 430-34. For a multispeed motor, each winding connection shall be considered separately.

(2) A thermal protector integral with the motor, approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload or failure to start. If the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) For motors larger than 1500 horsepower, a protective device employing embedded temperature detectors which cause current to the motor to be interruped when the motor attains a temperature rise greater than marked on the nameplate in an ambient of 40° C.

Standards for the application of embedded temperature detectors are given in the American Standards for Rotating Electrical Machinery, ASA C50-1 and C50-2.

(b) One Horsepower or Less, Manually Started. Each continuous duty motor rated at one horsepower or less which is not permanently installed, is manually started and is within sight from the controller location, shall be considered as protected against overcurrent by the overcurrent device protecting the conductors of the branch circuit. This branch circuit overcurrent device shall not be larger than that specified in Table 430-146, except that any such motor may be used at 125 volts or less on a branch circuit protected at 20 amperes. Any such motor which is not in sight from the controller location shall be protected as specified in Section 430-32(c). Any motor rated at one horsepower or less which is permanently installed, shall be protected in accordance with Section 430-32(c).

(c) One Horsepower or Less, Automatically Started. Any motor of one horsepower or less which is started automatically shall be protected against overcurrent by the use of one of the following means:

(1) A separate overcurrent device which is responsive to motor current. This device shall be rated or selected to trip at not more than 125 per cent of the motor full-load current rating for sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40° C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Section 430-34. For a multispeed motor, each winding connection shall be considered separately.

(2) A thermal protector integral with the motor, approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload or failure to start. Where the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) The motor shall be considered as being properly protected where it is part of an approved assembly which does not normally subject the motor to overloads and which is also equipped with other safety controls (such as the safety combustion controls of a domestic oil burner) which protect the motor against damage due to stalled rotor current. Where such protective equipment is used it shall be indicated on the nameplate of the assembly where it will be visible after installation.

(4) In case the impedance of the motor windings is sufficient to prevent overheating due to failure to start, the motor may be protected as specified in Section 430-32(b) for manually started motors.

Many alternating-current motors of less than 1/20 horsepower, such as clock motors, series motors, etc., and also some larger motors such as torque motors, come within this classification. It does not include split-phase motors having automatic switches to disconnect the starting windings.

(d) Wound-Rotor Secondaries. The secondary circuits of wound-rotor alternating-current motors, including conductors, controllers, resistors, etc., shall be considered as protected against overcurrent by the motor-running overcurrent device.

430-33. Intermittent and Similar Duty. A motor used for a condition of service which is inherently short time, intermittent, periodic, or varying duty, as illustrated by Table 430-22 (a-Exception), shall be considered as protected against overcurrent by the branch-circuit overcurrent device, provided the overcurrent protection does not exceed that specified in Tables 430-152 and 430-153.

Any motor application shall be considered to be for continuous duty unless the nature of the apparatus which it drives shall be such that the motor cannot operate continuously with load under any condition of use.

430-34. Selection or Setting of Protective Device. Where the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, nonadjustable circuit breakers, thermal cutouts, thermal relays, the heating elements of thermal trip motor switches, or possible settings of adjustable circuit breakers adequate to carry the load, the next higher size, rating, or setting may be used, but not higher than 140 per cent of the full-load current rating of sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40° C, and not higher than 130 per cent of the full-load current rating for all other motors.

In case it is not shunted during the starting period of the motor (see Section 430-35), the protective device shall have sufficient time delay to permit the motor to start and accelerate its load.

430-35. Shunting During Starting Period.

(a) In the case of a motor that is manually started (including starting with a magnetic starter having push-button control), the running overcurrent protection may be shunted or cut out of circuit during the starting period of the motor, provided the device by which the overcurrent protection is shunted or cut out cannot be left in the starting position, and fuses or time-delay circuit breakers rated or set at not over 400 per cent of the full-load current of the motor, are so located in the circuit as to be operative during the starting period of the motor.

(b) The motor-running overcurrent protection shall not be shunted or cut out during the starting period if the motor is automatically started.

430-36. Fuses—In Which Conductor. Where fuses are used for motor-running protection, a fuse shall be inserted in each ungrounded conductor.

Exception: A fuse shall also be inserted in a grounded conductor under the circumstances set forth in the note following Table 430-37.

430-37. Devices Other Than Fuses—In Which Conductor. Where devices other than fuses are used for motor-running overload protection, Table 430-37 shall govern the minimum allowable number and location of overcurrent units such as trip coils, relays, or thermal cutouts.

430-38. Number of Conductors Opened by Overcurrent Device. Motor-running protective devices, other than fuses, thermal cutouts, or thermal protectors, shall simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

430-39. Motor Controller as Running Overcurrent Protection. A motor controller may also serve as the running overcurrent device where the number of overcurrent units complies with Section 430-37 and where these overcurrent units are operative in both the starting and running position in the case of a direct-current motor, and in the running position in the case of an alternating-current motor. When a nonautomatic motor controller serves as the running overcurrent device, it is recommended that all ungrounded conductors be opened.

Table 430-37

Kind of Motor	**Supply System**	**Number and location of over-current units, such as trip coils, relays or thermal cutouts**
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C. ungrounded	1 in either conductor
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C., one conductor grounded	1 in ungrounded conductor
1-phase A.C. or D.C.	3-wire, 1-phase A.C. or D.C., grounded-neutral	1 in either ungrounded conductor
2-phase A.C.	3-wire, 2-phase A.C., ungrounded	2, one in each phase
2-phase A.C.	3-wire, 2-phase A.C., one conductor grounded	2 in ungrounded conductors
2-phase A.C.	4-wire, 2-phase A.C. grounded or ungrounded	2, one per phase in ungrounded conductors
2-phase A.C.	5-wire, 2-phase, A.C., grounded neutral or ungrounded	2, one per phase in any ungrounded phase wire
3-phase A.C.	3-wire, 3-phase A.C., ungrounded	*2 in any 2 conductors
3-phase A.C.	3-wire, 3-phase A.C., one conductor grounded	*2 in ungrounded conductors
3-phase A.C.	3-wire, 3-phase A.C. grounded-neutral	*2 in any 2 conductors
3-phase A.C.	4-wire, 3-phase A.C. grounded-neutral or ungrounded	*2 in any 2 conductors except the neutral

***Note:** Three running overcurrent units shall be used where three-phase motors are installed in isolated, inaccessible, or unattended locations, unless the motor is protected by other approved means.

UNATTENDED (Definition): Lacking the presence of a person capable of exercising responsible control of the motor under consideration.

430-40. Thermal Cutouts and Relays. Thermal cutouts, thermal relays, and other devices for motor-running protection which are not capable of opening short circuits, shall be protected by fuses or circuit breakers with ratings or settings of not over 4 times the rating of the motor for which they are designed, unless approved for group installation, and marked to indicate the maximum size of fuse by which they must be protected.

430-42. Motors on General Purpose Branch Circuits. Overcurrent protection for motors used on general purpose branch circuits as permitted in Article 210, shall be provided as follows:

(a) One or more motors without individual running overcurrent protection may be connected to general purpose branch circuits only where the limiting conditions specified for each of two or more motors in Section 430-53(a) are complied with.

(b) Motors of larger ratings than specified in Section 430-53(a) may be connected to general purpose branch circuits only in case each motor is protected by running overcurrent protection selected to protect the motor as specified in Section 430-32. Both the controller and the motor-running overcurrent device shall be approved for group installation with the protective device of the branch circuit to which the motor is connected. See Section 430-53.

(c) Where a motor is connected to a branch circuit by means of a plug and receptacle, and individual running overcurrent protection is omitted as provided in Section 430-42(a), a rating of the plug and receptacle shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts. Where individual overcurrent protection is required as provided in Section 430-42(b) for a motor or motor-operated appliance provided with an attachment plug for attaching to the branch circuit through a receptacle, the running overcurrent device shall be an integral part of the motor or of the appliance. The rating of the plug and receptacle shall be assumed to determine the rating of the circuit to which the motor may be connected, as provided in Article 210.

(d) The overcurrent device protecting a branch circuit to which a motor or motor-operated appliance is connected shall have sufficient time delay to permit the motor to start and accelerate its load.

430-43. Automatic Restarting. A motor-running protective device which can restart a motor automatically after overcurrent tripping shall not be installed unless approved for use with the motor which it protects. A motor which can restart automatically after shutdown shall not be installed so that its automatic restarting can result in injury to persons.

D. Motor-Branch-Circuit Short Circuit and Ground Fault Protection

430-51. General. The provisions of Part D specify overcurrent devices intended to protect the motor-branch-circuit conductors, the motor control apparatus, and the motors against overcurrent due to short circuits or grounds. They are in addition to or amendatory of the provisions of Article 240.

430-52. Rating or Setting for Individual Motor Circuit. The motor-branch-circuit overcurrent device shall be capable of carrying the starting current of the motor. Overcurrent protection shall be considered as being obtained when this overcurrent device has a rating or setting not exceeding the values given in Table 430-152 or 430-153; provided that where the overcurrent protection specified in the Table is not sufficient for the starting current of the motor, it may be increased, but shall in no case exceed 225 per cent of the motor full load current for sealed (hermetic type) refrigeration compressor motors of 400 KVA locked rotor or less, nor more than 400 per cent for other motors.

For a multispeed motor, a single short-circuit and ground fault protective device may be used for one or more windings of the motor provided the rating of the protective device does not exceed the above applicable percentage of the name plate rating of the smallest winding protected.

Branch circuit protective device ratings calculated on this basis are given in Columns 4, 5, 6, and 7, Table 430-146.

Where maximum protective device ratings shown on manufacturer's heater table for use with a motor controller are less than 15 amperes, the protective device rating shall not exceed the manufacturer's values marked on the equipment.

See Example No. 8, Chapter 9, and Diagram in Section 430-1.

430-53. Several Motors on One Branch Circuit. Two or more motors may be connected to the same branch circuit under the following conditions:

(a) Two or more motors each not exceeding one horsepower in rating and each having a full-load rated capacity not exceeding 6 amperes, may be used on a branch circuit protected at not more than 20 amperes at 125 volts or less, or 15 amperes at 600 volts or less. Individual running overcurrent protection is unnecessary for such motors unless required by the provisions of Section 430-32.

(b) If the branch circuit protective device is selected not to exceed that allowed by Section 430-52 for the motor of the smallest rating, two or more motors each having individual running overcurrent protection may be connected to a branch circuit when it can be determined that branch circuit protective device will not open under the most severe normal conditions of service which might be encountered.

(c) Except as provided for in Section 430-53(d), two or more motors of any rating, each having individual running overcurrent protection, may be connected to one branch circuit provided all of the following conditions are complied with:

(1) Each motor-running overcurrent device must be approved for group installation.

(2) Each motor controller must be approved for group installation.

(3) The branch circuit shall be protected by fuses having a rating not exceeding that specified in Section 430-52 for the largest motor connected to the branch circuit plus an amount equal to the sum of the full load current ratings of all other motors connected to the circuit.

(4) The branch circuit fuses must not be larger than allowed by Section 430-40 for the thermal cutout or relay protecting the smallest motor of the group.

(5) The conductors of any tap supplying a single motor need not have individual branch circuit protection, provided they comply with either of the following: (1) no conductor to the motor shall have an ampacity less than that of the branch circuit conductors, or (2) no conductor to the motor shall have an ampacity less than one-third that of the branch circuit conductors, with a minimum in accordance with Section 430-22; the conductors to the motor-running protective device being not more than 25 feet long and being protected from physical damage.

(d) The nameplate marking of a room air conditioner unit shall be used in determining the branch circuit requirements, and each unit shall be considered as a single-motor unit unless the nameplate is otherwise marked. For the purpose of this paragraph a room air conditioner is an alternating-current hermetic type air cooled window, console, or in-wall room air conditioner which is installed in the conditioned room. It covers equipment rated not greater than 250 volts, single phase. It also applies to such a room air conditioner, if it has provisions for heating.

430-54. Combined Overcurrent Protection. Motor-branch-circuit overcurrent protection and motor-running overcurrent protection may be combined in a single overcurrent device when the rating or setting of the device provides the running overcurrent protection specified in Section 430-32.

430-55. Overcurrent Devices—In Which Conductor. Overcurrent devices shall comply with the provisions of Section 240-11.

430-56. Size of Fuseholder. Where fuses are used for motor-branch-circuit protection, the fuseholders shall not be of a smaller size than required to accommodate the fuses specified by Table 430-146.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Table 430-146 may be used.

430-57. Rating of Circuit Breaker. A circuit breaker for motor branch-circuit protection shall have a continuous current rating of not less than 115 per cent of the full load current rating of the motor.

430-58. Feeder Taps in Inaccessible Location. If the location of the connection of a tap to the feeder conductors is not accessible, the motor-branch-circuit overcurrent device may be placed where it will be accessible, provided the conductors between the tap and the overcurrent device have the same ampacity as the feeder, or provided they have an ampacity of at least 1/3 that of the feeder and are not more than 25 feet long and are protected from physical damage.

430-59. Selection or Setting of Protective Device. In case the values for branch circuit protective devices determined by Table 430-152 or 430-153 do not correspond to the standard sizes or ratings of fuses, nonadjustable circuit breakers, or thermal devices, or possible settings of adjustable circuit breakers adequate to carry the load, the next higher size, rating or setting may be used. See Sections 240-6 and 240-7 for Standard Ratings.

E. Motor-Feeder Short-Circuit and Ground Fault Protection

430-61. General. The provisions of Part E specify overcurrent devices intended to protect feeder conductors supplying motors against overcurrents due to short circuits or grounds.

430-62. Rating or Setting—Motor Load.

(a) A feeder which supplies a specific fixed motor load and consisting of conductor sizes based on Section 430-24 shall be provided with overcurrent protection which shall not be greater than the largest rating or setting of the branch-circuit protective device, for any motor of the group (based on Tables 430-152 and 430-153), plus the sum of the full-load currents of the other motors of the group.

Where two or more motors of equal horsepower rating are the largest in the group, one of these motors shall be considered as the largest for the above calculations.

Where two or more motors of a group must be started simultaneously, it may be necessary to install larger feeder conductors and correspondingly larger ratings or settings of feeder overcurrent protection.

See Example No. 8, Chapter 9.

(b) For large capacity installations, where heavy capacity feeders are installed to provide for future additions or changes, the feeder overcurrent protection may be based on the rated ampacity of the feeder conductors.

430-63. Rating or Setting—Power and Light Loads. Where a feeder supplies a motor load, and in addition a lighting or a lighting and appliance load, the feeder overcurrent protective device may have a rating or setting sufficient to carry the lighting or the lighting and appliance load as determined in accordance with Articles 210 and 220, plus, for a single motor, the rating permitted by Section 430-52, and for two or more motors, the rating permitted by Section 430-62.

F. Motor Control Circuits

430-71. General. Part F contains modifications of the general requirements and applies to the particular conditions of motor control circuits.

CONTROL CIRCUIT (Definition): The control circuit of a control apparatus or system is the circuit which carries the electric signals directing the performance of the controller, but does not carry the main power circuit.

430-72. Overcurrent Protection. Conductors of control circuits shall be protected against overcurrent in accordance with Section 240-5, Exception No. 5.

Exception. Such conductors shall be considered as being properly protected by the branch-circuit overcurrent devices under any one of the following conditions:

(1) Where the rating or setting of the branch-circuit overcurrent device is not more than 500 per cent of the ampacity of the control-circuit conductors.

(2) Where the controlled device and the point of control (start and stop buttons, pressure switch, thermostatic switch, etc.) are both located on the same machine and the control circuit does not extend beyond the machine.

(3) Where the opening of the control circuit would create a hazard; as for example, the control circuit of fire-pump motors, and the like.

430-73. Mechanical Protection of Conductor. Where damage to a control circuit would constitute a hazard, all conductors of such remote-control circuit shall be installed in a raceway or be otherwise suitably protected from physical damage outside the control device itself.

Control circuits shall be so arranged that an accidental ground in the remote control devices will not start the motor.

430-74. Disconnection.

(a) Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means may consist of two separate devices, one of which disconnects the motor and the controller from the source of power supply for the motor, and the other, the control circuit from its power supply. Where the two separate devices are used, they shall be located immediately adjacent one to the other.

(b) Where a transformer or other device is used to obtain a reduced voltage for the control circuit and is located in the controller, such transformer or other device shall be connected to the load side of the disconnecting means for the control circuit.

G. Motor Controllers

430-81. General. The provisions of Part G are intended to require suitable controllers for all motors.

(a) Definition. For definition of "Controller," see Article 100. For the purpose of this Article, the term "Controller" includes any switch or device normally used to start and stop the motor.

(b) Stationary Motor of ⅛ Horsepower or Less. For a stationary motor rated at ⅛ horsepower or less, that is normally left running and is so constructed that it cannot be damaged by overload or failure to start, such as clock motors and the like, the branch-circuit overcurrent device may serve as the controller.

(c) Portable Motor of 1/3 Horsepower or Less. For a portable motor rated at 1/3 horsepower or less, the controller may be an attachment plug and receptacle.

430-82. Controller Design.

(a) Each controller shall be capable of starting and stopping the motor which it controls, and for an alternating-current motor shall be capable of interrupting the stalled-rotor current of the motor.

(b) Autotransformer. An autotransformer starter shall provide an off position, a running position, and at least one starting position. It shall be so designed that it cannot rest in the starting position, or in any position which will render inoperative the overcurrent protective device in the circuit.

(c) Rheostats. Rheostats shall conform to the following:

(1) Internal Connections. Motor-starting rheostats shall be so designed that the contact arm cannot be left on intermediate segments. The point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistor.

(2) Under-voltage Release, Direct-Current Motors. Motor-starting rheostats for direct-current motors operated from a constant voltage supply shall be equipped with automatic devices which will interrupt the supply before the speed of the motor has fallen to less than one-third its normal value.

430-83. Rating. The controller shall have a horsepower rating, which shall not be lower than the horsepower rating of the motor, except as follows:

Exception No. 1. Stationary Motor of 2 Horsepower or Less. For a stationary motor rated at 2 horsepower or less, and 300 volts or less, the controller may be a general-use switch having an ampere rating at least twice the full-load current rating of the motor.

On AC circuits, general use snap switches suitable only for use on AC (not general use AC-DC snap switches) may be used to control a motor rated at 2 horsepower or less and 300 volts or less having a full-load current rating not exceeding 80 per cent of the ampere rating of the switch.

Exception No. 2. Circuit Breaker as Controller. A branch circuit circuit breaker, rated in amperes only, may be used as a controller. Where this circuit breaker is also used for overcurrent protection, it shall conform to the appropriate provisions of this Article governing overcurrent protection.

Exception No. 3. Sealed (Hermetic-type) Refrigeration Compressor Motors. The motor controller shall have both a continuous duty full-load current rating, and a locked-rotor current rating, not less than the nameplate full-load current and locked-rotor current, respectively, of the compressor. In case the motor controller is rated in horsepower, but is without one or both of the foregoing current ratings, equivalent currents shall be determined from the rating as follows: Use Table 430-148, 430-149, or 430-150 to determine the equivalent full-load current rating. Use Table 430-151 to determine the equivalent locked-rotor current rating.

430-84. Need Not Open All Conductors. Except when it serves also as a disconnecting means (see Section 430-111), the controller need not open all conductors to the motor.

430-85. In Grounded Conductors. One pole of the controller may be placed in a permanently grounded conductor provided the controller is so designed that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

430-86. Motor Not in Sight from Controller. Where a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(a) The controller disconnecting means is capable of being locked in the open position.

(b) A manually operable switch which will disconnect the motor from its source of supply is placed within sight from the motor location.

430-87. Number of Motors Served by Each Controller. Each motor shall be provided with an individual controller.

Exception: For motors of 600 volts or less a single controller may serve a group of motors under any one of the following conditions:

(a) Where a number of motors drive several parts of a single machine or piece of apparatus such as metal and woodworking machines, cranes, hoists, and similar apparatus.

(b) Where a group of motors is under the protection of one overcurrent device as permitted in Section 430-53(a).

(c) Where a group of motors is located in a single room within sight from the controller location.

430-88. Adjustable-Speed Motors. Adjustable-speed motors that are controlled by means of field regulation shall be so equipped and connected that they cannot be started under weakened field, unless the motor is designed for such starting.

430-89. Speed Limitation. Machines of the following types shall be provided with speed limiting devices.

(a) Separately excited direct-current motors.

(b) Series motors.

(c) Motor-generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

Exception No. 1. Unless the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto, are such as to safely limit the speed.

Exception No. 2. Unless the machine is always under the manual control of a qualified operator.

430-90. Combination Fuseholder and Switch as Controller. The rating of a combination fuseholder and switch used as a motor-controller shall be such that the fuseholder will accommodate the size of fuse specified in Table 430-146, for motor-running overcurrent protection.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Table 430-146 may be used.

H. Disconnecting Means

430-101. General. The provisions of Part H are intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

See Diagram in Section 430-1.

430-102. In Sight from Controller Location. A disconnecting means shall be located in sight from the controller location, except as recognized in Section 422-26.

430-103. To Disconnect Both Motor and Controller. The disconnecting means shall disconnect both the motor and the controller from all ungrounded supply conductors. The disconnecting means may be in the same enclosure with the controller. See Section 430-113.

430-104. To Be Indicating. The disconnecting means shall plainly indicate whether it is in the open or closed position.

430-105. Grounded Conductors. One pole of the disconnecting means may disconnect a permanently grounded conductor, provided the disconnecting means is so designed that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

430-106. Service Switch as Disconnecting Means. Where an installation consists of a single motor, the service switch may serve as the disconnecting means, provided it conforms to the requirements of this Article, and is within sight from the controller location, except as recognized in Section 422-26.

430-107. Readily Accessible. One of the disconnecting means shall be readily accessible.

430-108. Every Switch. Every switch in the motor branch circuit within sight from the controller location shall comply with the requirements of Part H.

430-109. Type. The disconnecting means shall be a motor-circuit switch, rated in horsepower, or a circuit breaker, except as permitted in Sections 430-109 (a, b, c, d, or e).

(a) One-Eighth Horsepower or Less. For stationary motors of 1/8 horsepower or less, the branch-circuit overcurrent device may serve as the disconnecting means.

(b) Two Horsepower or Less. For stationary motors rated at 2 horsepower or less and 300 volts or less, the disconnecting means may be a general-use switch having an ampere rating not less than twice the full-load current rating of the motor.

On AC circuits, general use snap switches suitable only for use on AC (not general use AC-DC snap switches) may be used to disconnect a motor having a full-load current rating not exceeding 80 per cent of the ampere rating of the switch.

(c) Over Two Horsepower to and Including 50 Horsepower. The separate disconnecting means required for a motor with an autotransformer type of controller may be a general-use switch where all of the following provisions are complied with:

(1) The motor drives a generator which is provided with overcurrent protection.

(2) The controller (1) is capable of interrupting the stalled-rotor current of the motor, (2) is provided with a no-voltage release, and (3) is provided with running-over-current protection not exceeding 125 per cent of the motor full-load current rating.

(3) Separate fuses or a circuit breaker, rated or set at not more than 150 per cent of the motor full-load current, are provided in the motor branch circuit.

(d) Exceeding 50 Horsepower. For stationary motors rated at more than 50 horsepower, the disconnecting means may be a motor-circuit switch also rated in amperes, a general-use switch, or an isolating switch.

Isolation switches for motors exceeding 50 horsepower, not capable of interrupting stalled-rotor currents, shall be plainly marked "Do not open under load."

(e) Portable Motors. For portable motors an attachment plug and receptacle may serve as the disconnecting means.

430-110. Ampacity and Interrupting Capacity.

(a) The disconnecting means shall have an ampacity of at least 115 per cent of the full-load current rating of the motor.

(b) The disconnecting means for sealed (hermetic-type) refrigeration compressors shall be selected on the basis of the nameplate full-load current and locked-rotor current, respectively of the compressor motor as follows:

(1) The ampacity shall be at least 115 per cent of the nameplate full-load current.

(2) To determine the equivalent horsepower in complying with the requirements of Section 430-109, select the horsepower rating from Tables 430-148, 430-149, and 430-150 corresponding to the full-load current, and also the horsepower rating from Table 430-151 corresponding to the locked-rotor current. In case the nameplate full-load current and locked-rotor current do not correspond to the currents shown in Tables in Sections 430-148, 430-149, and 430-150, respectively, the horsepower rating corresponding to the next higher value shall be selected. In case two different horsepower ratings are obtained when applying Tables 430-148, 430-149, 430-150, and 430-151, a horsepower rating at least equal to the larger of the two values obtained shall be selected.

430-111. Switch or Circuit Breaker as Both Controller and Disconnecting Means. A switch or circuit breaker complying with the provisions of Section 430-83 may serve as both controller and disconnecting means provided it opens all ungrounded conductors to the motor, is protected by an overcurrent device (which may be the branch circuit fuses) which opens all ungrounded conductors to the switch or circuit breaker, and is of one of the following types:

(a) An air-break switch, operable directly by applying the hand to a lever or handle.

(b) A circuit breaker operable directly by applying the hand to a lever or handle.

(c) An oil switch used on a circuit whose rating does not exceed 600 volts or 100 amperes, or by special permission on a circuit exceeding this capacity where under expert supervision.

The oil switch or circuit breaker specified above may be both power and manually operable. If power operable, provision should be made to lock it in the open position.

The overcurrent device protecting the controller may be part of the controller assembly or may be separate.

An autotransformer type of controller is not included above and will require a separate disconnecting means.

430-112. Motors Served by a Single Disconnecting Means. Each motor shall be provided with individual disconnecting means.

Exception: For motors of 600 volts or less a single disconnecting means may serve a group of motors under any one of the following conditions:

(*a*) *Where a number of motors drive several parts of a single machine or piece of apparatus such as metal and woodworking machines, cranes, and hoists.*

(*b*) *Where a group of motors is under the protection of one set of overcurrent devices as permitted by Section 430-53*(*a*).

(*c*) *Where a group of motors is in a single room within sight from the location of the disconnecting means.*

The disconnecting means shall have a rating not less than is required by Section 430-109 for a single motor the rating of which equals the sum of the horsepowers or currents of all the motors of the group.

430-113. Energy From More Than One Source. Equipment receiving electrical energy from more than one source shall be provided with disconnecting means from each source of electrical energy adjacent to the equipment served.

J. Requirements for Over 600 Volts

430-121. General. The provisions of Part J recognize the additional hazard due to the use of high voltage. They are in addition to or amendatory of the other provisions of this article. Other requirements for circuits and equipment operating at more than 600 volts are in Article 710.

430-122. More Than 7500 Volts. Motors operating at more than 7500 volts between conductors shall be installed in fire-resistant motor rooms.

430-123. Motor Running Overcurrent (Overload) Protection. Running overcurrent protection for a motor of over 600 volts shall consist either of a circuit breaker, or of overcurrent units integral with the controller which shall simultaneously open all ungrounded conductors to the motor. The overcurrent device shall have a setting as specified elsewhere in this Article for motor-running overcurrent (overload) protection.

430-124. Short Circuit and Ground Fault Protection. Each motor branch circuit and feeder of more than 600 volts shall be protected against overcurrent by one of the following means:

(a) A circuit breaker of suitable rating so arranged that it can be serviced without hazard.

(b) Fuses of the oil-filled or other suitable type. Fuses shall be used with suitable disconnecting means or they shall be of a type which can also serve as the disconnecting means. They shall be so arranged that they cannot be re-fused or replaced while they are energized.

(c) Differential protection may be employed to protect an alternating-current motor, the motor control apparatus, and the branch-circuit conductors against overcurrent due to short circuits or grounds. When all these elements are included within the protected zone of a differential protective system, the ratings or settings specified in Section 430-52 do not apply.

DIFFERENTIAL PROTECTIVE SYSTEM (definition): A differential protective system is a combination of two or more sets of current transformers and a relay or relays energized from their interconnected secondaries.

The primaries of the current transformers are connected on both sides of the equipment to be protected, both ends of the motor phase windings being brought out for this purpose. All of the apparatus and circuits included between the sets of current transformer primaries constitute the protected zone. The current transformer secondaries and the relay elements are so interconnected that the relay elements respond only to a predetermined difference between the currents entering and leaving the protected zone. When actuated, the relay or relays serve to trip the branch-circuit circuit breaker, thus disconnecting the motor, control apparatus in the motor circuit and the branch-circuit conductors from the source of power and, in the case of a synchronous motor, de-energizing its field circuit.

430-126. Disconnecting Means. The circuit breaker or the fuses specified in Section 430-124 may constitute the disconnecting means if they conform to the other applicable requirements of this Article.

K. Protection of Live Parts — All Voltages

430-131. General. The provisions of Part K specify that live parts shall be protected in a manner judged adequate to the hazard involved.

430-132. Where Required. Exposed live parts of motors and controllers operating at 50 volts or more between terminals, shall be guarded against accidental contact by enclosure, or by location as follows:

(a) By installation in a room or enclosure which is accessible only to qualified persons;

(b) By installation on a suitable balcony, gallery or platform, so elevated and arranged as to exclude unqualified persons;

(c) By elevation 8 feet or more above the floor;

(d) So that it will be protected by a guard rail when the motor operates at 600 volts or less.

Exception: Stationary motors having commutators, collectors and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground.

430-133. Guards for Attendants. Where the live parts of motors or controllers operating at more than 150 volts to ground are guarded against accidental contact only by location as specified in Section 430-132, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms. Where necessary, steps and hand-rails should be installed on or about large machines to afford safe access to parts which must be examined or adjusted during operation.

L. Grounding

430-141. General. The provisions of Part L specify the grounding of motor and controller frames to prevent a potential above ground in the event of accidental contact between live parts and frames. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions.

430-142. Stationary Motors. The frames of stationary motors shall be grounded where any of the following conditions exist:

(a) supplied by means of metal-enclosed wiring.

(b) located in a wet place and not isolated nor guarded.

(c) in a hazardous location. (See Articles 500 to 517 inclusive.)

(d) the motor operates with any terminal at more than 150 volts to ground.

Grounding of the motor frame is preferable, but where the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

430-143. Portable Motors. The frames of portable motors which operate at more than 150 volts to ground shall be guarded or grounded. See Section 250-45(d) on grounding of portable appliances in other than residential occupancies.

Frames of motors which operate at less than 150 volts to ground shall be grounded where this can be readily accomplished. See Section 250-59(b) for color of grounding conductor.

430-144. Controllers. Controller cases, except those attached to ungrounded portable equipment and except the lined covers of snap switches, shall be grounded regardless of voltage.

430-145. Method of Grounding. Grounding where required shall be done in the manner specified in Article 250.

(a) Grounding Through Terminal Housings. Where the wiring to fixed motors is in Type AC metal-clad cable or metal raceways, junction boxes to house motor terminals shall be provided, and the armor of the cable or the metal raceways shall be connected to them in the manner specified in Article 250.

(b) Separation of Junction Box from Motor. The junction box required by Section 430-145(a) may be separated from the motor not more than 6 feet provided the leads to the motor are Type AC metal-clad cable or armored cord or are stranded leads enclosed in flexible or rigid conduit or electrical metallic tubing not smaller than ⅜ inch electrical trade size, the armor or raceway being connected both to the motor and to the box. Where stranded leads are used, protected as specified above, they shall not be larger than No. 10, and shall comply with other requirements of the Code for conductors to be used in raceways.

(c) Grounding of Controller Mounted Devices. Instrument transformer secondaries, and exposed noncurrent-carrying metal or other conductive parts or cases of instrument transformers, meters, instruments, and relays shall be grounded as specified in Sections 250-121 through 250-125.

Table 430-146. Overcurrent Protection for Motors
(See Tables 430-152 and 430-153)

These values are in accordance with Sections 430-6, 430-22, 430-32, 430-34, 430-52, 430-59, except as follows: The current values in Column 1 are to be taken from Tables 430-147 through 430-150, including footnotes, but the values shown for running protection in Columns 2 and 3 must be modified if nameplate full load current values are different, as provided in Section 130-6. The current values shown in Columns 2 and 3 must be reduced by 8 per cent for all motors other than open type motors marked to have a temperature rise of not over 40°C. as required by Section 430-32. For certain exceptions to the values in Columns 4, 5, 6, and 7, see Sections 430-52, and 430-59. See Section 430-53 for values to be used for several motors on one branch circuit. For running protection of motors, see Section 430-32. For setting of motor-branch-circuit protective devices, see Tables in Sections 430-152 and 430-153. For grouping of small motors under the protection of a single set of fuses, see Section 430-53.

Col. No. 1	2	3	4		5		6		7	
	For Running Protection of Motors		Maximum Allowable Rating or Setting of Branch Circuit Protective Devices							
Full load current rating of motor amperes	Maximum rating of nonadjustable protective devices.	Maximum setting of adjustable protective devices.	**With Code Letters** Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters F to V inclusive. **Without Code Letters** Same as above.		**With Code Letters** Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor start, Code letters B to E inclusive. Auto transformer start, Code letters F to V inclusive. **Without Code Letters** (Not more than 30 Amperes) squirrel cage and synchronous, auto transformer start, high reactance squirrel cage.*		**With Code Letters** Squirrel cage and synchronous auto transformer start, Code letters B to E inclusive. **Without Code Letters** (More than 30 amperes) Squirrel cage and synchronous auto transformer start, high reactance squirrel cage.*		**With Code Letters** All motors code letter A. **Without Code Letters** DC and wound rotor motors.	
	Amperes	Amperes	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)
1	2	1.25	15	15	15	15	15	15	15	15
2	3	2.50	15	15	15	15	15	15	15	15
3	4	3.75	15	15	15	15	15	15	15	15
4	6	5.0	15	15	15	15	15	15	15	15
5	8	6.25	15	15	15	15	15	15	15	15
6	8	7.50	20	15	15	15	15	15	15	15
7	10	8.75	25	20	20	15	15	15	15	15
8	10	10.0	25	20	20	20	20	20	15	15

***See note at end of table.**

9	12	11.25	30	30	25	20	20	20	15	15
10	15	12.50	30	30	25	20	20	20	15	15
11	15	13.75	35	30	30	30	25	30	20	20
12	15	15.00	40	30	30	30	25	30	20	20
13	20	16.25	40	40	35	30	30	30	20	20
14	20	17.50	45	40	35	30	30	30	25	30
15	20	18.75	45	40	40	30	30	30	25	30
16	20	20.00	50	40	40	40	35	40	25	30
17	25	21.25	60	50	45	40	35	40	30	30
18	25	22.50	60	50	45	40	40	40	30	30
19	25	23.75	60	50	50	40	40	40	30	30
20	25	25.00	60	50	50	40	40	40	30	30
22	30	27.50	70	70	60	50	45	50	35	40
24	30	30.00	80	70	60	50	50	50	40	40
26	35	32.50	80	70	70	70	60	70	40	40
28	35	35.00	90	70	70	70	60	70	45	50
30	40	37.50	90	100	80	70	60	70	45	50
32	40	40.00	100	100	80	70	70	70	50	50
34	45	42.50	110	100	90	70	70	70	60	70
36	45	45.00	110	100	90	100	80	100	60	70
38	50	47.50	125	100	100	100	80	100	60	70
40	50	50.00	125	100	100	100	80	100	60	70
42	50	52.50	125	125	110	100	90	100	70	70
44	60	55.00	125	125	110	100	90	100	70	70
46	60	57.50	150	125	125	100	100	100	70	70
48	60	60.00	150	125	125	100	100	100	80	100
50	60	62.50	150	125	125	100	100	100	80	100
52	70	65.00	175	150	150	125	110	125	80	100
54	70	67.50	175	150	150	125	110	125	90	100
56	70	70.00	175	150	150	125	125	125	90	100
58	70	72.50	175	150	150	125	125	125	90	100
60	80	75.00	200	150	150	125	125	125	90	100
62	80	77.50	200	175	175	125	125	125	100	100
64	80	80.00	200	175	175	150	150	150	100	100
66	80	82.50	200	175	175	150	150	150	100	100
68	90	85.00	225	175	175	150	150	150	110	125
70	90	87.50	225	175	175	150	150	150	110	125
72	90	90.00	225	200	200	150	150	150	110	125
74	90	92.50	225	200	200	150	150	150	125	125
76	100	95.00	250	200	200	175	175	175	125	125

Col. No. 1	2	3	4		5		6		7	
			Maximum Allowable Rating or Setting of Branch Circuit Protective Devices							
Full load current rating of motor amperes	For Running Protection of Motors Maximum rating of nonadjustable protective devices.	Maximum setting of adjustable protective devices.	**With Code Letters** Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters F to V inclusive. **Without Code Letters** Same as above.		**With Code Letters** Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor start, Code letters B to E inclusive. Auto transformer start, Code letters F to V inclusive. **Without Code Letters** (Not more than 30 Amperes) squirrel cage and synchronous, auto transformer start, high reactance squirrel cage.*		**With Code Letters** Squirrel cage and synchronous auto transformer start, Code letters B to E inclusive. **Without Code Letters** (More than 30 amperes) Squirrel cage and synchronous auto transformer start, high reactance squirrel cage.*		**With Code Letters** All motors code letter A. **Without Code Letters** DC and wound rotor motors.	
	Amperes	Amperes	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)	Fuses	Circuit Breakers (Non-adjustable Overload Trip)
78	100	97.50	250	200	200	175	175	175	125	125
80	100	100.00	250	200	200	175	175	175	125	125
82	110	102.50	250	225	225	175	175	175	125	125
84	110	105.00	250	225	225	175	175	175	150	150
86	110	107.50	300	225	225	175	175	175	150	150
88	110	110.00	300	225	225	200	200	200	150	150
90	110	112.50	300	225	225	200	200	200	150	150
92	125	115.00	300	250	250	200	200	200	150	150
94	125	117.50	300	250	250	200	200	200	150	150
96	125	120.00	300	250	250	200	200	200	150	150
98	125	122.50	300	250	250	200	200	200	150	150
100	125	125.00	300	250	250	200	200	200	150	150
105	150	131.50	350	300	300	225	225	225	175	175
110	150	137.50	350	300	300	225	225	225	175	175
115	150	144.00	350	300	300	250	250	250	175	175
120	150	150.00	400	300	300	250	250	250	200	200
125	175	156.50	400	350	350	250	250	250	200	200
130	175	162.50	400	350	350	300	300	300	200	200
135	175	169.00	450	350	350	300	300	300	225	225
140	175	175.00	450	350	350	300	300	300	225	225

145	200	181.50	450	400	400	300	300	300	225	225
150	200	187.50	450	400	400	300	300	300	225	225
155	200	194.00	500	400	400	350	350	350	250	250
160	200	200.00	500	400	400	350	350	350	250	250
165	225	206.00	500	500	450	350	350	350	250	250
170	225	213.00	500	500	450	350	350	350	300	300
175	225	219.00	600	500	450	350	350	350	300	300
180	225	225.00	600	500	450	400	400	400	300	300
185	250	231.00	600	500	500	400	400	400	300	300
190	250	238.00	600	500	500	400	400	400	300	300
195	250	244.00	600	500	500	400	400	400	300	300
200	250	250.00	600	500	500	400	400	400	300	300
210	250	263.00	800	600	600	500	450	500	350	350
220	300	275.00	800	600	600	500	450	500	350	350
230	300	288.00	800	600	600	500	500	500	350	350
240	300	300.00	800	600	600	500	500	500	400	400
250	300	313.00	800	700	800	500	500	500	400	400
260	350	325.00	800	700	800	600	600	600	400	400
270	350	338.00	1000	700	800	600	600	600	450	500
280	350	350.00	1000	700	800	600	600	600	450	500
290	350	363.00	1000	800	800	600	600	600	450	500
300	400	375.00	1000	800	800	600	600	600	450	500
320	400	400.00	1000	800	800	700	800	700	500	500
340	450	425.00	1200	...	1000	700	800	700	600	600
360	450	450.00	1200	...	1000	800	800	800	600	600
380	500	475.00	1200	...	1000	800	800	800	600	600
400	500	500.00	1200	...	1000	800	800	800	600	600
420	600	525.00	1600	...	1200	...	1000	...	800	700
440	600	550.00	1600	...	1200	...	1000	...	800	700
460	600	575.00	1600	...	1200	...	1000	...	800	700
480	600	600.00	1600	...	1200	...	1000	...	800	800
500	...	625.00	1600	...	1600	...	1000	...	800	800

* High-reactance squirrel-cage motors are those designed to limit the starting current by means of deepslot secondaries or double-wound secondaries and are generally started on full voltage.

Table 430-147. Full-Load Currents in Amperes Direct-Current Motors

The following values of full-load currents are for motors running at base speed.

HP	120V	240V
¼	2.9	1.5
⅓	3.6	1.8
½	5.2	2.6
¾	7.4	3.7
1	9.4	4.7
1½	13.2	6.6
2	17	8.5
3	25	12.2
5	40	20
7½	58	29
10	76	38
15		55
20		72
25		89
30		106
40		140
50		173
60		206
75		255
100		341
125		425
150		506
200		675

Table 430-148. Full-Load Currents in Amperes Single Phase Alternating Current Motors

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents, and multispeed motors will have full load current varying with speed, in which case the nameplate current ratings shall be used.

To obtain full-load currents of 208- and 200-volt motors, increase corresponding 230-volt motor full-load currents by 10 and 15 per cent, respectively.

The voltages listed are rated motor voltages. Corresponding nominal system voltages are 110 to 120, 220 to 240, 440 to 480.

HP	115V	230V	440V
⅙	4.4	2.2	..
¼	5.8	2.9	..
⅓	7.2	3.6	..
½	9.8	4.9	..
¾	13.8	6.9	..
1	16	8	..
1½	20	10	..
2	24	12	..
3	34	17	..
5	56	28	..
7½	80	40	21
10	100	50	26

Table 430-149. Full-Load Current
Two-Phase A.C. Motors (4-wire)

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full load current varying with speed, in which case the nameplate current rating shall be used. Current in common conductor of 2-phase, 3-wire system will be 1.41 times value given.

The voltages listed are rated motor voltages. Corresponding nominal system voltages are 110 to 120, 220 to 240, 440 to 480 and 550 to 600 volts.

	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
HP	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	4.8	2.4	1.2	1.0					
1	6.4	3.2	1.6	1.3					
1½	8.8	4.4	2.2	1.8					
2	11.2	5.6	2.8	2.2					
3		8	4	3.2					
5		13	7	6					
7½		19	9	8					
10		24	12	10					
15		34	17	14					
20		45	23	18					
25		55	28	22	6	47	24	19	4.7
30		67	34	27	7.5	56	29	23	5.7
40		88	44	35	9	75	37	31	7
50		108	54	43	11	94	47	38	9
60		129	65	52	13	111	56	44	11
75		158	79	63	16	140	70	57	13
100		212	106	85	21	182	93	74	17
125		268	134	108	26	228	114	93	22
150		311	155	124	31		137	110	26
200		415	208	166	41		182	145	35

†For 90 and 80 per cent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

Table 430-150. Full-Load Current* Three-Phase A.C. Motors

	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
HP	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7	3.5	1.8	1.4					
1½	10	5	2.5	2.0					
2	13	6.5	3.3	2.6					
3		9	4.5	4					
5		15	7.5	6					
7½		22	11	9					
10		27	14	11					
15		40	20	16					
20		52	26	21					
25		64	32	26	7	54	27	22	5.4
30		78	39	31	8.5	65	33	26	6.5
40		104	52	41	10.5	86	43	35	8
50		125	63	50	13	108	54	44	10
60		150	75	60	16	128	64	51	12
75		185	93	74	19	161	81	65	15
100		246	123	98	25	211	106	85	20
125		310	155	124	31	264	132	106	25
150		360	180	144	37		158	127	30
200		480	240	192	48		210	168	40

For full-load currents of 208- and 200-volt motors, increase the corresponding 220-volt motor full-load current by 6 and 10 per cent, respectively.

* These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full load current varying with speed, in which case the nameplate current rating shall be used.

† For 90 and 80 per cent P. F. the above figures shall be multiplied by 1.1 and 1.25 respectively.

The voltages listed are rated motor voltages. Corresponding nominal system voltages are 110 to 120, 220 to 240, 440 to 480 and 550 to 600 volts.

Table 430-151
Locked-Rotor Current Conversion Table

As Determined from Horsepower and Voltage Rating
For Use Only With Sections 430-83, Exception No. 3, and 430-110(b)

Conversion Table

Max HP Rating	Maximum Motor Locked-Rotor Amperes					
	Single Phase		Two or Three Phase			
	115 V	230 V	110 V	220 V	440 V	550 V
½	58.8	29.4	24	12	6	4.8
¾	82.8	41.4	33.6	16.8	8.4	6.6
1	96	48	42	21	10.8	8.4
1½	120	60	60	30	15	12
2	144	72	78	39	19.8	15.6
3	204	102	—	54	27	24
5	336	168	—	90	45	36
7½	480	240	—	132	66	54
10	600	300	—	162	84	66
15	—	—	—	240	120	96
20	—	—	—	312	156	126
25	—	—	—	384	192	156
30	—	—	—	468	234	186
40	—	—	—	624	312	246
50	—	—	—	750	378	300
60	—	—	—	900	450	360
75	—	—	—	1110	558	444
100	—	—	—	1476	738	588
125	—	—	—	1860	930	744
150	—	—	—	2160	1080	864
200	—	—	—	2880	1440	1152

Table 430-152. Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors Marked with a Code Letter Indicating Locked Rotor KVA

Type of Motor	Per Cent of Full-Load Current Fuse Rating See also Table 430-146, Columns 4, 5, 6, 7)	Circuit-Breaker Setting Instantaneous Type	Time Limit Type
All AC single-phase and polyphase squirrel cage and synchronous motors with full-voltage, resistor or reactor starting:			
Code Letter A	150	....	150
Code Letter B to E	250	———	200
Code Letter F to V	300	....	250
All AC squirrel cage and synchronous motors with auto-transformer starting:			
Code Letter A	150	....	150
Code Letter B to E	200	....	200
Code Letter F to V	250	....	200

For certain exceptions to the values specified see Sections 430-52 and 430-54. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in Section 430-52.

Synchronous motors of the low-torque, low-speed type (usually 450 RPM or lower), such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors not marked with a Code Letter, see Table 430-153.

Table 430-153. Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors not Marked with a Code Letter Indicating Locked Rotor KVA

Type of Motor	Per Cent of Full-Load Current Fuse Rating (See also Table 430-146, Columns 4, 5, 6, 7	Circuit-Breaker Setting Instantaneous Type	Circuit-Breaker Setting Time Limit Type
Single-phase, all types	300	....	250
Squirrel-cage and synchronous (full-voltage, resistor and reactor starting)	300	....	250
Squirrel-cage and synchronous (auto-transformer starting)			
Not more than 30 amperes	250	....	200
More than 30 amperes	200	....	200
High-reactance squirrel-cage			
Not more than 30 amperes	250	....	250
More than 30 amperes	200	....	200
Wound-rotor	150	....	150
Direct-current			
Not more than 50 H.P.	150	250	150
More than 50 H.P.	150	175	150
Sealed (Hermetic Type) Refrigeration Compressor* 400 KVA locked-rotor or less	**175	....	**175

For certain exceptions to the values specified see Sections 430-52, and 430-59. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in Section 430-52.

Synchronous motors of the low-torque low-speed type (usually 450 R.P.M. or lower) such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors marked with a Code Letter, see Table 430-152.

*The locked rotor KVA is the product of the motor voltage and the motor locked rotor current (LRA) given on the motor nameplate divided by 1,000 for single-phase motors, or divided by 580 for 3-phase motors.

**This value may be increased to 225 per cent if necessary to permit starting.

ARTICLE 445 — GENERATORS

445-1. Location. Generators shall be located in dry places, and also so as to meet the requirements for motors in Section 430-14. Generators installed in hazardous locations as described in Articles 500-503, or in other locations as described in Articles 510-517, 520, 530, and 665, shall also comply with the provisions of those Articles.

Waterproof covers shall be provided for use in emergency.

445-2. Marking. Each generator shall be provided with a nameplate giving the maker's name, the rating in kilowatts or kilovolt-amperes, the normal volts and amperes corresponding to the rating, and the revolutions per minute.

445-3. Drip Pans. Generators shall be provided with suitable drip pans if required by the authority enforcing this Code.

445-4. Overcurrent Protection.

(a) Constant-Potential Generators. Constant-potential generators, except alternating-current generators and their exciters, shall be protected from excessive current by circuit breakers or fuses.

(b) Two-Wire Generators. Two-wire, direct-current generators may have overcurrent protection in one conductor only if the overcurrent device is actuated by the entire current generated, except that in the shunt field. The overcurrent device shall not open the shunt field.

(c) 65 Volts or Less. Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 per cent of their full-load rated current.

(d) Balancer Sets. Two-wire, direct-current generators used in conjunction with balancer sets to obtain neutrals for 3-wire systems shall be equipped with overcurrent devices which will disconnect the 3-wire system in the case of excessive unbalancing of voltages or currents.

(e) 3-Wire, Direct-Current Generators. Three-wire, direct-current generators, whether compound or shunt wound, shall be equipped with overcurrent devices, one in each armature lead, and so connected as to be actuated by the entire current from the armature. Such overcurrent devices shall consist either of a double-pole, double-coil circuit breaker, or of a 4-pole circuit breaker connected in the main and equalizer leads and tripped by two overcurrent devices, one in each armature lead. Such protective devices shall be so interlocked that no one pole can be opened without simultaneously disconnecting both leads of the armature from the system.

445-5. Size of Conductors. The conductors from the generator terminals to supplied equipment shall have an ampacity not less than 115 per cent of the nameplate current rating of the generator. Neutral conductors shall be the same size as the conductors of the outside legs.

445-6. Protection of Live Parts. Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact where accessible to unqualified persons.

445-7. Guards for Attendants. Where necessary for the safety of attendants the provisions of Section 430-133 shall be complied with.

445-8. Grounding. If a generator operates at a terminal voltage in excess of 150 volts to ground, the frame shall be grounded in the manner specified in Article 250. If the frame is not grounded, it shall be permanently and effectively insulated from the ground.

445-9. Bushings. Where wires pass through an opening in an enclosure, conduit box, or barrier, a bushing shall be used to protect the conductors from the edges of the opening having sharp edges. The bushing shall have smooth, well rounded surfaces where it may be in contact with the conductors. If used where there may be a presence of oils, grease, or other contaminants, the bushing shall be made of a material not deleteriously affected.

ARTICLE 450 — TRANSFORMERS AND TRANSFORMER VAULTS

(Including Secondary Ties)

450-1. Application. This Article applies to the installation of all transformers except: (1) current transformers; (2) dry-type transformers which constitute a component part of other apparatus and which conform to the requirements for such apparatus; (3) transformers for use with X-ray and high-frequency; (4) transformers used with Class 1 low-voltage power circuits or Class 2 remote control low energy power and signal circuits which shall conform to Article 725; (5) transformers for sign and outline lighting which shall conform to Article 600; and (6) transformers for electric discharge lighting which shall conform to Article 410.

This Article applies to the installation of transformers in hazardous locations except as modified by Article 500.

Supplementary rules are found also in Article 710, Circuits and Equipment Operating at More than 600 Volts Between Conductors; and Service Installations Over 600 Volts as referred to in Article 230.

A. General Provisions

450-2. Location. Transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance. The location of oil insulated transformers and transformer vaults is covered in Sections 450-24, 450-25, and 450-41; dry type transformers in Section 450-21 and askarel insulated in Section 450-23.

450-3. Overcurrent Protection. Overcurrent protection shall conform to the following. As used in this Section, the word "transformer" means a transformer or polyphase bank of two or three single phase transformers operating as a unit.

(a) Primary Side. Each transformer shall be protected by an individual overcurrent device in the primary connection, rated or set at not more than 250 per cent of the rated primary current of the transformer, except that an individual overcurrent device is not required when the primary circuit overcurrent device provides the protection specified in this Section, and except as provided in Section 450-3(b).

(b) Primary and Secondary Side. A transformer having an overcurrent device in the secondary connection, rated or set at not more than 250 per cent of the rated secondary current of the transformer, or a transformer equipped with a coordinated thermal overload protection by the manufacturer, is not required to have an individual overcurrent device in the primary connection provided the primary feeder overcurrent device is rated or set to open at a current value not more than six times the rated current of the transformer for transformers having not more than six per cent impedance, and not more than four times rated current of the transformer for transformers having more than six but not more than ten per cent impedance.

(c) Potential (Voltage) Transformers. Potential transformers should be protected with primary fuses. The fuse rating should not exceed 10 amperes for circuits of 600 volts or less, and 3 amperes for circuits of more than 600 volts. A resistor should be connected in series with high tension fuses when necessary to limit the possible short-circuit current to a value within the interrupting capacity of the fuse.

450-5. Secondary Ties. As used in this Section, the word "transformer" means a transformer or a bank of transformers operating as a unit. A secondary tie is a circuit operating at 600 volts or less between phases which connects two power sources or power supply points, such as the secondaries of two transformers. The tie may consist of one or more conductors per phase.

(a) Tie Circuits. Tie circuits shall be provided at each end with overcurrent protection as required in Article 240 of this Code, except under the conditions described in Sections 450-5 (a-1 and a-2), in which cases the overcurrent protection may be in accordance with Section 450-5 (a-3).

(1) Loads at Transformer Supply Points Only. Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with Article 240, the rated ampacity of the tie shall be not less than 67 per cent of the rated secondary current of the largest transformer connected to the secondary tie system.

(2) Loads Connected Between Transformer Supply Points. Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Article 240, the rated ampacity of the tie shall be not less than 100 per cent of the rated secondary current of the largest transformer connected to the secondary tie system except as otherwise provided in Section 450-5 (a-4).

(3) Tie Circuit Protection. Under the conditions described in Sections 450-5(a-1 and 2), both ends of each tie conductor shall be equipped with a protective device which will open at a predetermined temperature of the tie conductor under short circuit conditions. This protection shall consist of one of the following: (1) a fusible link cable connector, terminal or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of approved construction and characteristics according to the operating voltage and the type of insulation on the tie conductors, or (2) automatic circuit breakers actuated by devices having comparable current-time characteristics.

(4) Interconnection of Phase Conductors Between Transformer Supply Points. Where the tie consists of more than one conductor per phase, the conductors of each phase shall be interconnected in order to establish a load supply point, and the protection specified in Section 450-5(a-3) shall be provided in each tie conductor at this point, except as follows:

Exception: Loads may be connected to the individual conductors of a multiple-conductor tie without interconnecting the conductors of each phase and without the protection specified in Section 450-5(a-3) at load connection points provided; the tie conductors of each phase have a combined capacity not less than 133 per cent of the rated secondary current of the largest transformer connected to the secondary tie system; the total load of such taps does not exceed the rated secondary current of the largest transformer; the loads are equally divided on each phase and on the individual conductors of each phase as far as practicable.

(5) Tie Circuit Control. Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end which when open will de-energize the associated tie conductors and limiters. The current rating of the switch shall be not less than the rated current of the conductors connected to the switch. It shall be capable of opening its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

(b) Overcurrent Protection for Secondary Connections. When secondary ties are used an overcurrent device rated or set at not more than 250 per cent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer, and in addition an automatic circuit breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

450-6. Parallel Operation. Transformers may be operated in parallel and switched as a unit provided that the overcurrent protection for each transformer meets the requirements of 450-3.

To obtain balanced division of load current, both transformers should have the same rated per cent impedance and be operated on the same voltage-ratio tap.

450-7. Guarding. Transformers shall be guarded as follows:

(a) Mechanical Protection. Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are located where they are exposed to physical damage.

(b) Case or Enclosure. Dry-type transformers shall be provided with a noncombustible moisture-resistant case or enclosure which will provide reasonable protection against the accidental insertion of foreign objects.

(c) Exposed Live Parts. The transformer installation shall conform with the provisions for guarding of live parts in Section 110-16.

(d) Voltage Warning. The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

450-8. Grounding. Exposed noncurrent carrying metal parts of transformer installations including fences, guards, etc., shall be grounded where required under the conditions and in the manner prescribed for electrical equipment and other exposed metal parts in Article 250.

450-9. Marking. Each transformer shall be provided with a nameplate giving the name of the manufacturer; rated kilovolt-amperes, frequency, primary and secondary voltage; and the amount and kind of insulating liquid where used and the transformer rating exceeds 25 kva. Where Class B insulation is used in the construction of dry-type transformers rated more than 100 kva, the nameplate shall indicate the temperature rise for this insulation system.

B. Specific Provisions Applicable to Different Types of Transformers

450-21. Dry-Type Transformers Installed Indoors. Transformers rated 112½ kva or less shall have a separation of at least 12 inches from combustible material unless separated therefrom by a fire-resistant heat-insulating barrier, or unless of a rating not exceeding 600 volts and completely enclosed except for ventilating openings.

Transformers of more than 112½ kva rating shall be installed in a transformer room of fire-resistant construction unless they are constructed with 80° C rise (Class B) or 150° C rise (Class H) insulation, and are separated from combustible material not less than 6 feet horizontally and 12 feet vertically or are separated therefrom by a fire-resistant heat-insulating barrier.

Transformers rated more than 35,000 volts shall be installed in a vault. See Part C of this Article.

450-23. Askarel-Insulated Transformers Installed Indoors. Askarel-insulated transformers rated in excess of 25 kva shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent shall be connected to a chimney or flue which will carry such gases outside the building. Askarel-insulated transformers rated more than 35,000 volts shall be installed in a vault.

450-24. Oil-Insulated Transformers Installed Indoors. Oil-insulated transformers shall be installed in a vault constructed as specified in this Article except as follows:

(a) Not Over 112½ kva Total Capacity. The provisions for transformer vaults specified in Part C of this Article apply except that the vault may be constructed of reinforced concrete not less than 4 inches thick.

(b) Not Over 600 Volts. A vault is not required provided suitable arrangements are made where necessary to prevent a transformer oil fire igniting other materials, and the total transformer capacity in one location does not exceed 10 kva in a section of the building classified as combustible, or 75 kva where the surrounding structure is classified as fire-resistant construction.

(c) Furnace Transformers. Electric furnace transformers of a total rating not exceeding 75 kva may be installed without a vault in a building or room of fire-resistant construction provided suitable arrangements are made to prevent a transformer oil fire spreading to other combustible material.

(d) Detached Buildings. Transformers may be installed in a building which does not conform with the provisions specified in this Code for transformer vaults, provided neither the building nor its contents present a fire hazard to any other building or property, and provided the building is used only in supplying electric service and the interior is accessible only to qualified persons.

450-25. Oil-Insulated Transformers Installed Outdoors. Combustible material, combustible buildings and parts of buildings, fire escapes, door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on, attached to, or adjacent to a building or combustible material. Space separations, fire-resistant barriers, automatic water spray systems and enclosures which confine the oil of a ruptured transformer tank are recognized safeguards. One or more of these safeguards shall be applied according to the degree of hazard involved in cases where the transformer installation presents a fire hazard. Oil enclosures may consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse crushed stone. Oil enclosures shall be provided with trapped drains in cases where the exposure and the quantity of oil involved are such that removal of oil is important.

C. Provisions for Transformer Vaults

450-41. Location. Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

450-42. Walls, Roof, and Floor. The walls and roofs of vaults shall be constructed of reinforced concrete, brick, load bearing tile, concrete block, or other fire resistive constructions which have adequate structural strength for the conditions, and a minimum fire resistance of 2½ hours according to American Standard A2.1—Methods of Fire Tests of Building Construction and Materials (ASTM Standard E119-58; NFPA No. 251). The floors of vaults in contact with the earth shall be of concrete not less than 4 inches thick but when the vault is constructed with a vacant space or other stories below it, the floor shall have adequate structural strength for the load imposed thereon and a minimum fire resistance of 2½ hours.

450-43. Doorways. Vault doorways shall be protected as follows:

(a) Type of Door. Each doorway leading into a building shall be provided with a tight-fitting door of a type approved for openings in Class A situations as defined in the NFPA Standard for the Installation of Fire Doors and Windows, No. 80 (National Fire Codes, Vol. 4). The authority enforcing this Code may require such a door for an exterior wall opening or on each side of an interior wall opening where conditions warrant.

(b) Sills. A door sill or curb of sufficient height to confine within the vault the oil from the largest transformer shall be provided and in no case shall the height be less than 4 inches.

(c) Locks. Entrance doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to qualified persons. Locks and latches shall be so arranged that the door may be readily and quickly opened from the inside.

450-44. Ventilation. The ventilation shall be adequate to prevent a transformer temperature in excess of the values prescribed in ASA C57.12-58.

450-45. Ventilation Openings. When required by Section 450-44, openings for ventilation shall be provided in accordance with the following:

(a) Location. Ventilation openings shall be located as far away as possible from doors, windows, fire escapes, and combustible material.

(b) Arrangement. Vaults ventilated by natural circulation of air may have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof; or all of the area required for ventilation may be provided in one or more openings in or near the roof.

(c) Size. In the case of vaults ventilated to an outdoor area without using ducts or flues the combined net area of all ventilating openings after deducting the area occupied by screens, gratings, or louvers, shall be not less than 3 square inches per kva of transformer capacity in service, except that the net area shall be not less than 1 square foot for any capacity under 50 kva.

(d) Covering. Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(e) Dampers. Where automatic dampers are used in the ventilation openings of vaults containing oil-insulated transformers, the actuating device should be made to function at a temperature resulting from fire and not at a temperature which might prevail as a result of an overheated transformer or bank of transformers. Automatic dampers should be so designed and constructed to minimize the possibility of accidental closing.

(f) Ducts. Ventilating ducts shall be constructed of fire-resistant material.

450-46. Drainage. Where practicable, vaults containing more than 100 kva transformer capacity shall be provided with a drain or other means which will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain when provided.

450-47. Water Pipes and Accessories. Any pipe or duct systems foreign to the electrical installation should not enter or pass through a transformer vault. Where the presence of such foreign systems cannot be avoided, appurtenances thereto which require maintenance at regular intervals shall not be located inside the vault. Arrangements shall be made where necessary to avoid possible trouble from condensation, leaks and breaks in such foreign systems. Piping or other facilities provided for fire protection or for water-cooled transformers are not deemed to be foreign to the electrical installation.

450-48. Storage in Vaults. Materials shall not be stored in transformer vaults.

ARTICLE 460 — CAPACITORS

460-1. Application. This Article applies to installation of capacitors on electric circuits in or on buildings.

Exception No. 1. Capacitors that are components of other apparatus shall conform to the requirements for such apparatus.

Exception No. 2. Capacitors in hazardous locations shall comply with additional requirements in Articles 500-517.

460-2. Location. An installation of capacitors in which any single unit contains more than three gallons of combustible liquid shall be in a vault conforming to Part C of Article 450.

460-3. Mechanical Protection. Capacitors shall be protected from physical damage by location or by suitable fences, barriers or other enclosures.

460-4. Cases and Supports. Capacitors shall be provided with noncombustible cases and supports.

460-5. Transformers Used with Capacitors. Transformers that are components of capacitor installations and are used for the purpose of connecting the capacitor to a power circuit shall be installed in accordance with Article 450. The kva rating shall not be less than 135 per cent of the capacitor rating in kvar.

460-6. Drainage of Stored Charge. Capacitors shall be provided with a means of draining the stored charge.

(a) Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts or less within one minute after the capacitor is disconnected from the source of supply in the case of capacitors rated 600 volts or less and in five minutes in the case of capacitors rated more than 600 volts.

(b) Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used. The windings of motors, of transformers, or of other equipment directly connected to capacitors without a switch or overcurrent device interposed, constitutes a suitable discharge means.

460-7. Power Factor Correction — Motor Circuit. The total kvar rating of capacitors which are connected on the load side of a motor controller shall not exceed the value required to raise the no-load power factor of the motor to unity.

460-8. Conductor Rating.

(a) The ampacity of capacitor circuit conductors shall be not less than 135 per cent of the rated current of the capacitor. The ampacity of conductors which connect a capacitor to the terminals of a motor or to motor circuit conductors, shall be not less than one-third the ampacity of the motor circuit conductors but not less than 135 per cent of the rated current of the capacitor.

(b) Overcurrent Protection.

(1) An overcurrent device shall be provided in each ungrounded conductor.

Exception: A separate overcurrent device is not required on the load-side of a motor running overcurrent device.

(2) The rating or setting of the overcurrent device shall be as low as practicable.

(c) Disconnecting Means.

(1) A disconnecting means shall be provided in each ungrounded conductor.

Exception: A separate disconnecting means is not required for a capacitor connected on the load side of a motor overcurrent device.

(2) The disconnecting device need not open all ungrounded conductors simultaneously.

(3) The disconnecting device may be used for disconnecting the capacitor from the line as a regular operating procedure.

(4) The continuous ampacity of the disconnecting device shall be not less than 135 per cent of the rated current of the capacitor.

460-9. Rating or Setting of the Motor-Running Overcurrent Device. Where a motor installation includes a capacitor connected on the load side of the motor-running overcurrent device, and the overcurrent device used can be adjusted, the rating or setting of the motor overcurrent device shall be determined as provided in Section 430-32, except that instead of using the full-load rated current of the motor as provided in that Section a lower value corresponding with the improved power-factor of the motor circuit shall be used. Section 430-22 applies with respect to the rating of the motor circuit conductors.

460-10. Grounding. Capacitor cases shall be grounded in accordance with Article 250.

460-11. Guarding. All live parts of capacitors which are connected to circuits of more than 600 volts between conductors and are accessible to unqualified persons, shall be enclosed or isolated. For isolation by elevation, see Section 710-34(f).

460-12. Marking. Each capacitor shall be provided with a nameplate giving the maker's name, rated voltage, frequency, kvar, or amperes, number of phases, and if filled with a combustible liquid, the amount of liquid in gallons. When filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate if a capacitor has a discharge device inside the case.

ARTICLE 470 — RESISTORS AND REACTORS

For Rheostats see Section 430-82.

470-1. Location. Resistors and reactors shall not be placed where exposed to physical damage. Where in the immediate vicinity of easily ignitible material they shall be of the oil-immersed type or shall be enclosed in metal boxes or cabinets. See Article 500 for Hazardous Locations.

470-2. Space Separation. Unless attached to a switchboard or other noncombustible material, or unless mounted as provided in Section 470-3, resistors and reactors shall be separated from combustible material by a distance of not less than 1 foot.

470-3. On or In a Proximity to Combustible Material. Where placed within a distance of 1 foot from combustible material, resistors and reactors shall be installed as follows:

(a) Slab or Panel. They shall be attached to a slab or panel of noncombustible, nonabsorptive material such as slate, soapstone, or marble.

(b) Size of Slab. The slab shall extend beyond the edges of the device and shall have a thickness proportioned to the size and weight of the device but shall not be less than ½ inch thick.

(c) Supports. The slab shall be secured in position by supports independent of those fastening the device to the slab. Bolts which support the device shall be countersunk at least ⅛ inch below the rear surface of the slab and shall be covered with insulating material.

470-4. Contacts. Fixed and movable contacts shall be so designed that arcing will be kept at a minimum.

470-5. Reactor Materials. Reactors shall be composed of noncombustible materials, and shall be mounted on noncombustible bases.

470-6. Mounting. Enclosures when mounted on plain surfaces shall make contact with such surfaces only at the point of support, an air space of at least ¼ inch being maintained between the enclosures and surfaces.

470-7. Conductor Insulation. Insulated conductors used for connection between resistance elements and controllers shall be suitable for an operating temperature of not less than 90°C (194°F). For elevator motor starting service, see Section 620-11(a).

Exception: For motor starting service other conductor insulations may be used.

470-8. Incandescent Lamps as Resistors. Incandescent lamps may be used as protective resistors for automatic controllers, or may by special permission be used as resistors in series with other devices and shall conform to the following:

(a) Mounting. They shall be mounted in porcelain receptacles on noncombustible supports.

(b) Voltage. They shall be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated.

(c) Nameplate. They shall be provided with a nameplate, permanently attached, giving the wattage and voltage of the lamp to be used in each receptacle.

(d) Not Carry Main Current. They shall not carry or control the main current nor constitute the regulating resistance of the device.

ARTICLE 480 — STORAGE BATTERIES

480-1. Scope. The provisions of this Article shall apply to all stationary installations of storage batteries using acid or alkali as the electrolyte and consisting of a number of cells connected in series with a nominal voltage in excess of 16 volts.

480-2. Definition of Nominal Battery Voltage. The nominal battery voltage shall be calculated on the basis of 2.0 volts per cell for the lead-acid type, and 1.2 volts per cell for the alkali type.

480-3. Wiring and Apparatus Supplied from Batteries. Wiring, appliances, and apparatus supplied from storage batteries shall be subject to the requirements of this Code applying to wiring, appliances, and apparatus operating at the same voltage, except as otherwise provided for communication systems in Article 800.

480-4. Insulation of Batteries of Not Over 250 Volts. The provisions of this Section shall apply to storage batteries having the cells so connected as to operate at a nominal battery voltage not exceeding 250 volts.

(a) Lead-Acid Batteries. Cells in lead-lined wood tanks, where the number of cells in series does not exceed 25, shall be supported individually on glass or glazed porcelain insulators. Where the number of the cells in series exceeds 25, the cells shall be supported individually on oil insulators.

(b) Alkali-Type Batteries. Cells of the alkali type in jars made of conducting material shall be installed in trays of nonconducting material, with not over 20 cells in a series circuit in any one such tray, or the cells may be supported singly or in groups on porcelain or other suitable insulators.

(c) Unsealed Jars. Cells in unsealed jars made of nonconductive material shall be assembled in trays of glass or supported on glass or glazed porcelain insulators; or, where installed on a rack, shall be supported singly or in groups on glass or other suitable insulators.

(d) Sealed Rubber Jars. Cells in sealed rubber or composition containers shall require no additional insulating support where the total nominal voltage of all cells in series does not exceed 150 volts. Where the total voltage exceeds 150 volts, batteries shall be sectionalized into groups of 150 volts or less and each group shall have the individual cells installed in trays or on racks. Where trays or racks are required for this type of cell, such trays or racks shall be supported on glass or glazed porcelain insulators or oil-type insulators.

(e) Sealed Glass or Plastic Jars. Cells in sealed glass jars or in sealed jars of approved heat resistant plastic, with or without wood trays, require no additional insulation.

480-5. Insulation of Batteries of Over 250 Volts. The provisions of Section 480-4 shall apply to storage batteries having the cells so connected as to operate at a nominal voltage exceeding 250 volts and, in addition, the provisions of this section shall also apply to such batteries. Cells shall be installed in groups having a total nominal voltage of not over 250 volts, in trays or on racks supported on oil insulators.

Exception No. 1. Where each individual cell, or sub-group in the tray or rack, is supported on oil insulators, no additional insulation for the group need be provided.

Exception No. 2. Cells of not over 10 ampere-hour capacity in sealed glass jars may be grouped in trays, the total nominal voltage of all cells in such group not to exceed 250 volts, and each such tray to be supported on glass or glazed porcelain insulators, the trays being mounted on racks supported on oil insulators with a total nominal voltage of not over 500 volts for all cells in series on each such insulated rack.

Maximum protection is secured by sectionalizing high-voltage batteries into cell groups insulated from each other.

480-6. Racks and Trays. Racks and trays shall conform to the following:

(a) Racks. Racks, as required in this Article, refer to frames designed to support cells or trays. They shall be substantial, and made of:

(1) Wood, so treated as to be resistant to deteriorating action by the electrolyte; or

(2) Metal, so treated as to be resistant to deteriorating action by the electrolyte, and provided with nonconducting members directly supporting the cells or with suitable insulating material on conducting members; or

(3) Other similar suitable construction.

(b) Trays. Trays refer to frames such as crates or shallow boxes usually of wood or other nonconducting material, so constructed or treated as to be resistant to deteriorating action by the electrolyte.

480-7. Battery Rooms. Battery rooms shall conform to the following:

(a) Use. Separate battery rooms or enclosures shall be required only for batteries in unsealed jars and tanks where the aggregate capacity at the 8-hour discharge rate exceeds 5 kilowatt hours.

(b) Ventilation. Provision shall be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture in the battery room.

(c) Wiring Method. In storage battery rooms, bare conductors, open wiring, Type MI cable, type ALS cable, or conductors in rigid conduit or electrical metallic tubing shall be used as the wiring method. Rigid metal conduit, or electrical metallic tubing, where used, shall be of corrosion-resistant material or shall be suitably protected from corrosion.

(d) Varnished-Cambric Conductors. Varnished-cambric-covered conductors, Type V, shall not be used.

(e) Bare Conductors. Bare conductors shall not be taped.

(f) Terminals. Where metal raceway or other metallic covering is used in the battery room, at least 12 inches of the conductor at the end connected to a cell terminal shall be free from the raceway or metallic covering and shall be bushed by a substantial glazed insulating bushing. The end of the raceway shall be sealed tightly to resist the entrance of electrolyte by spray or by creepage. Sealing compound, rubber insulating tape or other suitable material shall be used for this purpose.

Chapter 5. Special Occupancies

ARTICLE 500 — HAZARDOUS LOCATIONS

500-1. Scope. The provisions of Articles 500-503 apply to locations in which the authority enforcing this Code judges the apparatus and wiring to be subject to the conditions indicated by the following classifications. It is intended that each room, section or area (including motor and generator rooms, and rooms for the enclosure of control equipment) shall be considered individually in determining its classification. Except as modified in Articles 500-503, all other applicable rules contained in this Code shall apply to electrical apparatus and wiring installed in hazardous locations. For definitions of "approved" and "explosion-proof" as used in these Articles, refer to Article 100; "dust-ignition-proof" is defined in Section 502-1.

Equipment and associated wiring approved as intrinsically safe may be installed in any hazardous location for which it is approved, and the provisions of Articles 500-517 need not apply to such installation. Intrinsically safe equipment and wiring are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. Abnormal conditions will include accidental damage to any part of the equipment or wiring, insulation or other failure of electrical components, application of over-voltage, adjustment and maintenance operations, and other similar conditions.

Through the exercise of ingenuity in the layout of electrical installations for hazardous locations, it is frequently possible to locate much of the equipment in less hazardous or in nonhazardous areas and thus to reduce the amount of special equipment required. In some cases, hazards may be reduced or hazardous areas limited or eliminated by adequate positive-pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure.

It is recommended also that the Code enforcing authority be familiar with such recorded industrial experience as well as with such standards of the National Fire Protection Association as may be of use in the classification of various areas with respect to hazard. For further information see NFPA No. 30, Flammable and Combustible Liquids Code; No. 32, Standard for Dry Cleaning Plants; No. 35M, Organic Coatings Manufacture; and No. 36, Standard for Solvent Extraction Plants.

For protection against static electricity hazards, refer to the standards of the National Fire Protection Association on this subject.

Where rigid conduit is used in hazardous locations, it is necessary to have all threaded joints made up wrench tight to minimize sparking when fault current flows through the conduit system. Where it is impractical to make a threaded joint tight, a bonding jumper should be utilized.

All conduit referred to herein shall be threaded with standard conduit cutting die which provides ¾" taper per foot. Such conduit shall be made up wrench tight to minimize sparking when fault current flows through the conduit system. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

500-2. Special Precaution. The intent of Articles 500-503 is to require a form of construction of equipment, and of installation that will insure safe performance under conditions of proper use and maintenance. It, therefore, is assumed that inspection authorities and users will exercise more than ordinary care with regard to installation and maintenance.

The characteristics of various atmospheric mixtures of hazardous gases, vapors and dusts depend on the specific hazardous material involved. It is necessary therefore that equipment be approved not only for the class of location but also for the specific gas, vapor or dust that will be present.

For purposes of testing and approval, various atmospheric mixtures have been grouped on the basis of their hazardous characteristics, and facilities have been made available for testing and approval of equipment for use in the following atmospheric groups:

Group A, Atmospheres containing acetylene;

Group B, Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gas;

Group C, Atmospheres containing ethyl ether vapors, ethylene, or cyclopropane;

Group D, Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, or natural gas;

Group E, Atmospheres containing metal dust, including aluminum, magnesium, and their commerical alloys, and other metals of similarly hazardous characteristics.

Group F, Atmospheres containing carbon black, coal or coke dust;

Group G, Atmospheres containing flour, starch, or grain dusts.

500-3. Specific Occupancies. See Articles 510 to 517 inclusive for rules applying to garages, aircraft hangars, gasoline dispensing and service stations, bulk storage plants, finishing processes, and flammable anesthetics.

500-4. Class I Locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include the following:

(a) Class I, Division 1. Locations (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions, (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or (3) in which breakdown or faulty operation of equipment or processes which might release hazardous concentrations of flammable gases or vapors, might also cause simultaneous failure of electrical equipment.

This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction apparatus using volatile flammable solvents; portions of cleaning and dyeing plants where hazardous liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile, flammable materials are stored in open, lightly stoppered, or easily ruptured containers, and all other locations where hazardous concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(b) Class I, Division 2. Locations (1) in which volatile flammable liquids or flammable gases are handled, processed or used, but in which the hazardous liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment, (2) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of the ventilating equipment, or (3) which are adjacent to Class I, Division 1 locations, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which, in the judgment of the Code enforcing authority, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of hazardous material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that should receive consideration in determining the classification and extent of each hazardous area.

Piping without valves, checks, meters and similar devices would not ordinarily be deemed to introduce a hazardous condition even though used for hazardous liquids or gases. Locations used for the storage of hazardous liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless subject to other hazardous conditions also.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier shall be classed as Division 2 locations if the outside of conduit and enclosures is a nonhazardous area.

500-5. Class II Locations. Class II locations are those which are hazardous because of the presence of combustible dust. Class II locations shall include the following:

(a) Class II, Division 1. Locations (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures, (2) where mechanical failure or abnormal operation of machinery or equipment might cause such mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes, or (3) in which dusts of an electrically conducting nature may be present.

This classification usually includes the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpers, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust producing machinery and equipment in grain processing plants, starch plants, sugar pulverizing plants, malting plants, hay grinding plants, and other occupancies of similar nature; coal pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitible mixtures.

Combustible dusts which are electrically nonconducting include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Electrically conducting nonmetallic dusts include dusts from pulverized coal, coke and charcoal. Dusts containing magnesium or aluminum are particularly hazardous and every precaution must be taken to avoid ignition and explosion.

(b) Class II, Division 2. Locations in which combustible dust will not normally be in suspension in the air, or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus, in quantities sufficient to produce explosive or ignitible mixtures, but (1) where deposits or accumulations of such dust may be sufficient to interfere with the safe dissipation of heat from electrical equipment or apparatus, or (2) where such deposits or accumulations of dust on, in, or in the vicinity of electrical equipment might be ignited by arcs, sparks or burning material from such equipment.

Locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on, or in the vicinity of electrical equipment, would include rooms and areas containing only closed spouting and conveyors, closed bins or hoppers, or machines and equipment from which appreciable quantities of dust would escape only under abnormal operating conditions; rooms or areas adjacent to locations described in Section 500-5(a), and into which explosive or ignitible concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitible concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms where dust producing materials are stored or handled only in bags or containers; and other similar locations.

500-6. Class III Locations. Class III locations are those which are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitible mixtures. Class III locations shall include the following:

(a) Class III, Division 1. Locations in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured or used.

Such locations usually include some parts of rayon, cotton and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

Easily ignitible fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior and other materials of similar nature.

(b) Class III, Division 2. Locations in which easily ignitible fibers are stored or handled (except in process of manufacture).

ARTICLE 501 — CLASS I INSTALLATIONS — HAZARDOUS LOCATIONS

501-1. General. The general rules of this Code shall apply to the installation of electrical wiring and equipment in locations classified as Class I under Section 500-4 except as modified by this Article.

501-2. Transformers and Capacitors. The installation of transformers and capacitors shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, transformers and capacitors shall conform to the following:

(1) Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults, which shall conform to Sections 450-41 to 450-48 inclusive, and in addition, (1) there shall be no door or other communicating opening between the vault and the hazardous area, (2) ample ventilation shall be provided for the continuous removal of hazardous gases or vapor, (3) vent openings or ducts shall lead to a safe location outside of buildings, and (4) vent ducts and openings shall be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction.

(2) Not Containing a Liquid that Will Burn. Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to the requirements of Section 501-2(a-1), or (2) be approved for Class I locations (explosion-proof).

(b) Class I, Division 2. In Class I, Division 2 locations, transformers and capacitors shall conform to Sections 450-21 to 450-25 inclusive.

501-3. Meters, Instruments and Relays. The installation of meters, instruments and relays shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 location, meters, instruments and relays, including kilowatt-hour meters, instrument transformers and resistors, rectifiers and thermionic tubes, shall be provided with enclosures approved for Class I locations.

(b) Class I, Division 2. In Class I, Division 2 locations, meters, instruments and relays shall conform to the following:

(1) Contacts. Switches and circuit-breakers, and make and break contacts of push buttons, relays, and alarm bells or horns, shall have enclosures approved for Class I locations, unless general purpose enclosures are provided, and current interrupting contacts are (1) immersed in oil, (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors, or (3) in circuits which under normal conditions do not release sufficient energy to ignite a specific hazardous atmospheric mixture.

(2) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, and rectifiers, which are used in or in connection with meters, instruments and relays, shall conform to Section 501-3(a), except that enclosures may be of general purpose type when such equipment is without make and break or sliding contacts (other than as provided in Section 501-3(b) (1) above) and when the maximum operating temperature of any exposed surface will not exceed eighty per cent (80%) of the ignition temperature in degrees Centigrade of the gas or vapor involved as determined by A.S.T.M. test procedure (Designation D286-30).

(3) Without Make or Break Contacts. Transformer windings, impedance coils, solenoids, and other windings which do not incorporate sliding or make or break contacts shall be provided with enclosures which may be of general purpose type where vents adequate to permit prompt escape of any gases or vapors are provided.

(4) General Purpose Assemblies. Where an assembly is made up of components for which general purpose enclosures are acceptable under Sections 501-3(b-1, 2, 3), a single general purpose enclosure is acceptable for the assembly. Where such an assembly includes any of the equipment described in Section 501-3(b-2) the maximum obtainable surface temperature of any component of the assembly shall be clearly and permanently indicated on the outside of the enclosure.

(5) Fuses. Where general purpose enclosures are permitted under Paragraphs 501-3.(b), (1), (2), (3), (4), fuses for overcurrent protection of the instrument circuits may be mounted in general purpose enclosures provided such fuses do not exceed 3 ampere rating at 120 volts and provided each such fuse is preceded by a switch conforming to Paragraph 501-3.(b).(1).

501-4. Wiring Methods. Wiring methods shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. All boxes, fittings, and joints shall be threaded for connection to conduit or cable terminations, and shall be explosion-proof. Threaded joints shall be made up with at least five threads fully engaged. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings. Where necessary to employ flexible connections, as at motor terminals, flexible fittings approved for Class I locations (explosion-proof) shall be used.

(b) Class I, Division 2. In Class I, Division 2 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for Class I locations, or approved Type MC or ALS cable with termination fittings approved for Class I locations shall be the wiring method employed. Type MI, MC or ALS cable shall be installed in a manner to avoid tensile stress at the termination fittings. Boxes, fittings and joints need not be explosion proof except as required by Sections 501-5(b) (1) and (2). Where provision must be made for limited flexibility, as at motor terminals, flexible metal fittings, flexible metal conduit with approved fittings, or flexible cord approved for extra hard usage and provided with approved bushed fittings shall be used. An additional conductor for grounding shall be included in the flexible cord unless other acceptable means of grounding are provided.

501-5. Sealing and Drainage. Seals are provided in conduit and cable systems to prevent the passage of gases, vapors or flames from one portion of the electrical installation to another through the conduit. Such communication through Type MI cable is inherently prevented by construction of the cable, but sealing compound is used in cable termination fittings to exclude moisture and other fluids from the cable insulation, and shall be of a type approved for the conditions of use. Seals in conduit and cable systems shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, seals shall be located as follows:

(1) In each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors or other apparatus which may produce arcs, sparks or high temperatures. Seals shall be placed as close as practicable and in no case more than 18 inches from such enclosures.

(2) In each conduit run of 2-inch size or larger entering the enclosure or fitting housing terminals, splices or taps, and within 18 inches of such enclosure or fitting.

Where two or more enclosures for which seals are required under Sections 501-5(a-1, 2) are connected by nipples or by runs of conduit not more than 36 inches long, a single seal in each such nipple connection or run of conduit would be sufficient if located not more than 18 inches from either enclosure. Ordinary conduit fittings of the "L," "T" or "Cross" type would not usually be classed as enclosures when not larger than the trade size of the conduit.

(3) In each conduit run leaving the Class I, Division 1 hazardous area. The sealing fitting may be located on either side of the boundary of such hazardous area, but shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 1 hazardous area, will not enter or be communicated to the conduit beyond the seal. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the Division 1 hazardous area.

(b) Class I, Division 2. In Class I, Division 2 locations, seals shall be located as follows:

(1) For conduit connections to enclosures which are required to be approved for Class I locations, seals shall be provided in conformance to Sections 501-5(a-1, 2). All portions of the conduit run or nipple between the seal and such enclosure shall conform to Section 501-4(a).

(2) In each conduit run passing from the Class I, Division 2 hazardous area into a nonhazardous area. The sealing fitting may be located on either side of the boundary of such hazardous area, but shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 2 hazardous area, will not enter or be communicated to the conduit beyond the seal. Rigid conduit shall be used between the sealing fitting and the point at which the conduit leaves the hazardous area, and a threaded connection shall be used at the sealing fitting. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the hazardous area.

(c) Class I, Divisions 1 and 2. Where seals are required, they shall conform to the following:

(1) Fittings. Enclosures for connections or for equipment shall be provided with approved integral means for sealing, or sealing fittings approved for Class I locations shall be used. Sealing fittings shall be accessible.

(2) Compound. Sealing compound shall be approved for the purpose, shall not be affected by the surrounding atmosphere or liquids, and shall not have a melting point of less than 93°C. (200°F.).

(3) Thickness of Compound. In the completed seal, the minimum thickness of the sealing compound shall be not less than the trade size of the conduit, and in no case less than ⅝ inch.

(4) Splices and Taps. Splices and taps shall not be made in fittings intended only for sealing with compound, nor shall other fittings in which splices or taps are made be filled with compound.

(5) Assemblies. In an assembly where equipment which may produce arcs, sparks or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other, the entire assembly shall be approved for Class I locations. Seals in conduit connections to the compartment containing splices or taps shall be provided in Class I, Division 1 locations where required by Section 501-5(a-2).

(d) Drainage.

(1) Control Equipment. Where there is probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

(2) Motors and Generators. Where the authority enforcing this Code judges that there is probability that liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid. If means to prevent accumulation or to permit periodic draining are judged necessary, such means shall be provided at the time of manufacture, and shall be deemed an integral part of the machine.

(3) Canned Pumps, Process Connections for Flow, Pressure or Analysis Measurement, Etc., frequently depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system. An additional approved seal or barrier shall be provided with an adequate drain between the seals in such a manner that leaks would be obvious.

See also the last paragraph of footnote in Section 500-4 (b).

501-6. Switches, Circuit Breakers, Motor Controllers and Fuses. Switches, circuit breakers, motor controllers and fuses shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, switches, circuit breakers, motor controllers and fuses, including push buttons, relays and similar devices, shall be provided with enclosures, and the enclosure in each case together with the enclosed apparatus shall be approved as a complete assembly for use in Class I locations.

(b) Class I, Division 2. Switches, circuit breakers, motor controllers and fuses in Class I, Division 2 locations shall conform to the following:

(1) Type Required. Circuit breakers, motor controllers and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with enclosures approved for Class I locations, unless general purpose enclosures are provided and (1) the interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors, or (2) the current interrupting contacts are oil-immersed and the device is approved for locations of this class and division.

This includes service and branch circuit switches and circuit breakers; motor controllers, including push buttons, pilot switches, relays and motor-overload protective devices; and switches and circuit breakers for the control of lighting and appliance circuits. Oil-immersed circuit breakers and controllers of ordinary general use type may not confine completely the arc produced in the interruption of heavy overloads, and specific approval for locations of this class and division is therefore necessary.

(2) Isolating Switches. Enclosures for disconnecting and isolating switches without fuses and which are not intended to interrupt current may be of general purpose type.

(3) Fuses. For the protection of motors, appliances and lamps, except as provided in Section 501-6(b-4), (1) standard plug or cartridge fuses may be used provided they are placed within enclosures approved for the purpose and for the location, or (2) fuses of a type in which the operating element is immersed in oil or other approved liquid, or is enclosed within a chamber hermetically sealed against the entrance of gases and vapors may be used provided they are approved for the purpose and are placed within general purpose enclosures.

(4) Fuses or Circuit Breakers for Overcurrent Protection. When not more than 10 sets of approved enclosed fuses, or not more than 10 circuit breakers which are not intended to be used as switches for the interruption of current, are installed for branch or feeder circuit protection in any one room, area or section of this class and division, the enclosures for such fuses or circuit breakers may be of general purpose type, provided the fuses or circuit breakers are for the protection of circuits or feeders supplying lamps in fixed positions only.

A set of fuses is construed to mean a group containing as many fuses as are required to perform a single protective function in a circuit. For example, a group of 3 fuses protecting an ungrounded three-phase circuit, and a single fuse protecting the ungrounded conductor of an identified two-wire single-phase circuit, would each be considered as a set of fuses. Fuses conforming to Section 501-6(b-3) need not be included in counting the 10 sets of fuses permitted in general purpose enclosures.

501-7. Control Transformers and Resistors. Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, transformers, impedance coils and resistors, together with any switching mechanism associated with them, shall be provided with enclosures approved for Class I locations (explosion-proof).

(b) Class I, Division 2. In Class I, Division 2 locations, control transformers and resistors shall conform to the following:

(1) Switching Mechanisms. Switching mechanisms used in conjunction with transformers, impedance coils and resistors shall conform to Section 501-6(b).

(2) Coils and Windings. Enclosures for windings of transformers, solenoids or impedance coils may be of general purpose type, but shall be provided with vents adequate to permit prompt escape of gases or vapors that may enter the enclosure.

(3) Resistors. Resistors shall be provided with enclosures and the assembly shall be approved for Class I locations, unless resistance is nonvariable and maximum operating temperature, in degrees Centigrade, will not exceed eighty per cent (80%) of the ignition temperature of the gas or vapor involved as determined by ASTM test procedure (Designation D 286-30).

501-8. Motors and Generators. Motors and generators shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, motors, generators and other rotating electrical machinery shall be (1) approved for Class I locations (explosion-proof), or (2) of the totally enclosed type supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area, so arranged to prevent energizing of the machine until ventilation has been established and the enclosure has been purged with at least ten (10) volumes of air, and also arranged to automatically de-energize the equipment when the air supply fails, or (3) of the totally enclosed inert-gas-filled type supplied with a suitable reliable source of inert gas for pressuring the enclosure, with devices provided to insure a positive pressure in the enclosure and arranged to automatically de-energize the equipment when the gas supply fails. Totally enclosed motors of types (2) or (3) shall have no external surface with an operating temperature in degrees Centigrade in excess of eighty per cent (80%) of the ignition temperature of the gas or vapor involved, as determined by ASTM test procedure (Designation: D-286-30). Appropriate devices shall also be provided to detect any increase in temperature of the motor beyond design limits and automatically de-energize the equipment. Auxiliary equipment shall be of a type approved for the location in which it is installed.

(b) Class I, Division 2. In Class I, Division 2 locations, motors, generators and other rotating electrical machinery in which are employed sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, either while starting or while running, shall be approved for Class I locations (explosion-proof), unless such sliding contacts, switching mechanisms and resistance devices are provided with enclosures approved for such locations.

This rule does not prohibit installation of open or nonexplosion-proof enclosed motors, such as squirrel cage induction motors, without brushes, switching mechanism, etc., in Class I, Division 2 locations.

501-9. Lighting Fixtures. Lamps shall be installed in fixtures which shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, lighting fixtures shall conform to the following:

(1) Approved Fixtures. Each fixture shall be approved as a complete assembly for locations of this class, and shall be clearly marked to indicate the maximum wattage of lamps for which it is approved. Fixtures intended for portable use shall be specifically approved as a complete assembly for that use.

(2) Physical Damage. Each fixture shall be protected against physical damage by a suitable guard or by location.

(3) Pendant Fixtures. Pendant fixtures shall be suspended by and supplied through threaded rigid conduit stems and threaded joints shall be provided with set-screws or other effective means to prevent loosening. For stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose and for the location shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(4) Supports. Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class I locations.

(b) Class I, Division 2. In Class I, Division 2 locations, lighting fixtures shall conform to the following:

(1) Portable Lamps. Portable lamps shall conform to Section 501-9(a-1).

(2) Fixed Lighting. Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided. Where lamps are of a size or type which may, under normal operating conditions, reach surface temperatures exceeding eighty per cent (80%) of the ignition temperature in degrees Centigrade of the gas or vapor involved, as determined by ASTM test procedure (Designation D 286-30), fixtures shall conform to Section 501-9(a-1).

(3) Pendant Fixtures. Pendant fixtures shall be suspended by threaded rigid conduit stems or by other approved means. For rigid stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(4) Supports. Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose.

(5) Switches. Switches which are a part of an assembled fixture or of an individual lampholder shall conform to the requirements of Section 501-6(b-1).

(6) Starting Equipment. Starting and control equipment for mercury-vapor and fluorescent lamps shall conform to the requirements of Section 501-7(b).

501-10. Utilization Equipment, Fixed and Portable. Utilization equipment, fixed and portable, shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, utilization equipment, including electrically-heated and motor-driven equipment shall be approved for Class I locations.

(b) Class I, Division 2. In Class I, Division 2 locations, utilization equipment, fixed and portable, shall conform to the following:

(1) Heaters. Electrically-heated utilization equipment shall be approved for Class I locations.

(2) Motors. Motors of motor-driven utilization equipment shall conform to Section 501-8(b).

(3) Switches, Circuit-breakers, and Fuses. Switches, circuit-breakers and fuses shall conform to Section 501-6(b).

501-11. Flexible Cords, Class I, Divisions 1 and 2. A flexible cord may be used only for connection between a portable lamp or other portable utilization equipment and the fixed portion of its supply circuit and where used shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Section 400-13, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) suitable seals shall be provided where the flexible cord enters boxes, fittings or enclosures of explosion-proof type.

Refer to Section 501-13 when flexible cords are exposed to liquids having a deleterious effect on the conductor insulation.

501-12. Receptacles and Attachment Plugs, Class I, Divisions 1 and 2. Receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class I locations.

501-13. Conductor Insulation Class I, Divisions 1 and 2. Where condensed vapors or liquids may collect on or come in contact with the insulation on conductors, such insulation shall be of a type approved for use under such conditions or the insulation shall be protected by a sheath of lead or by other approved means.

501-14. Signal, Alarm, Remote-control and Communication Systems. Signal, alarm, remote-control and communication systems shall conform to the following:

(a) Class I, Division 1. In Class I, Division 1 locations, all apparatus and equipment of signalling, alarm, remote-control and communication systems, irrespective of voltage, shall be approved for Class I locations, and all wiring shall conform to Sections 501-4(a) and 501-5(a and c).

(b) Class I, Division 2. In Class I, Division 2 locations, signal, alarm, remote-control and communication systems shall conform to the following:

(1) Contacts. Switches and circuit breakers, and make and break contacts of push buttons, relays, and alarm bells or horns, shall have enclosures approved for Class I locations, unless general purpose enclosures are provided and current interrupting contacts are (1) immersed in oil, or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors, or (3) in circuits which under normal conditions do not release sufficient energy to ignite a specific hazardous atmospheric mixture.

(2) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes and rectifiers shall conform to Section 501-3 (b-2).

(3) Protectors. Enclosures which may be of general purpose type shall be provided for lightning protective devices and for fuses.

(4) All wiring shall conform to Section 501-4.(b) and 501-5.(b) and (c).

501-15. Live Parts, Class I, Divisions 1 and 2. There shall be no exposed live parts.

501-16. Grounding, Class I, Divisions 1 and 2. Wiring and equipment shall be grounded in conformity with the following:

(a) Exposed Parts. The exposed noncurrent-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or other utilization equipment, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Article 250 of this Code.

(b) Bonding. The locknut-bushing and double-locknut types of contacts shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc. between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in Section 501-4(b), bonding jumpers with proper fittings shall be provided around such conduit.

(c) Lightning Protection. Each ungrounded service conductor of a wiring system in a Class I location, when supplied from an overhead line in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

Also refer to Section 502-3.

(d) Grounded Service Conductor Bonded to Raceway. Wiring in a Class I location, when supplied from a grounded alternating current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

(e) Transformer Ground Bonded to Raceway. Wiring in a Class I location, when supplied from a grounded alternating current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have an ampacity not less than 1/5 that of the service conductors, and shall in no case be smaller than No. 10 when of soft copper, or No. 12 when of medium or hard-drawn copper.

(f) Multiple Grounds. Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in Section 501-16(d and e) shall not be abandoned while any other grounding connection remains connected to the supply system.

ARTICLE 502 — CLASS II INSTALLATIONS — HAZARDOUS LOCATIONS

502-1. General. The general rules of this Code shall apply to the installation of electrical wiring and apparatus in locations classified as Class II under Section 500-5 except as modified by this Article.

"Dust-ignition-proof," as used in this Article, shall mean enclosed in a manner which will exclude ignitible amounts of dusts or amounts which might affect performance or rating and which, when installation and protection are in conformance with this Code, will not permit arcs, sparks or heat otherwise generated or liberated inside of the enclosure, to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

Equipment installed in Class II locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of any organic dust deposits that may occur. Dust which is carbonized or is excessively dry is highly susceptible to spontaneous ignition. In general, maximum surface temperatures under actual operating conditions shall not exceed 165°C. (329°F.) for equipment which is not subject to overloading, and 120°C. (248°F.) for equipment such as motors, power transformers, etc., which may be overloaded.

Equipment and wiring of the type defined in Article 100 as explosion-proof is not required in Class II locations, and may not be acceptable unless approved for such locations.

502-2. Transformers and Capacitors. The installation of transformers and capacitors shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, transformers and capacitors shall conform to the following:

(1) Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults conforming to Sections 450-41 to 450-48 inclusive, and in addition (1) door or other openings communicating with the hazardous area shall have self-closing fire doors on both sides of the wall, and the doors shall be carefully fitted and provided with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault, (2) vent openings and ducts shall communicate only with the outside air, and (3) suitable pressure-relief openings communicating with the outside air shall be provided.

(2) Not Containing a Liquid that Will Burn. Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to Sections 450-41 to 450-48 inclusive, or (2) be approved as a complete assembly including terminal connections for Class II locations.

(3) Metal Dusts. No transformer or capacitor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present.

(b) Class II, Division 2. In Class II, Division 2 locations, transformers and capacitors shall conform to the following:

(1) Containing a Liquid that Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed in vaults conforming to Sections 450-41 to 450-48 inclusive.

(2) Containing Askarel. Transformers containing askarel and rated in excess of 25 kva shall (1) be provided with pressure-relief vents, (2) be provided with means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue which will carry such gases outside the building and (3) have an air space of not less than 6 inches between the transformer cases and any adjacent combustible material.

(3) Dry-Type Transformers. Dry-type transformers shall be installed in vaults or shall (1) have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings, and (2) operate at voltages not exceeding 600 volts.

502-3. Surge Protection, Class II, Divisions 1 and 2. In geographical locations where lightning disturbances are prevalent, wiring systems in Class II locations shall, when supplied from overhead lines, be suitably protected against high-voltage surges. This protection shall include suitable lightning protective devices, interconnection of all grounds, and surge-protective capacitors.

Interconnection of all grounds shall include grounds for primary and secondary lightning protective devices, secondary system grounds if any, and grounds of conduit and equipment of the interior wiring system. For ungrounded secondary systems, secondary lightning protective devices may be provided both at the service and at the point where the secondary system receives its supply, and the intervening secondary conductors may be accepted as the metallic connection between the secondary protective devices, provided grounds for the primary and secondary devices are metallically interconnected at the supply end of the secondary system and the secondary devices are grounded to the raceway system at the load end of the secondary system.

Surge protective capacitors shall be of a type especially designed for the duty, shall be connected to each ungrounded service conductor, and shall be grounded to the interior conduit system. Capacitors shall be protected by 30-ampere fuses of suitable type and voltage rating, or by automatic circuit breakers of suitable type and rating and shall be connected to the supply conductors on the supply side of the service disconnecting means.

502-4. Wiring Methods. Wiring methods shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

(1) Fittings and Boxes. Fittings and boxes shall be provided with threaded bosses for connection to conduit or cable terminations, shall have close fitting covers, and shall have no openings (such as holes for attachment screws) through which dust might enter, or through which sparks or burning material might escape. Fittings and boxes in which taps, joints or terminal connections are made, or which are used in locations where dusts are of an electrically conducting nature shall be dust-ignition-proof and approved for Class II locations.

(2) Flexible Connections. Where necessary to employ flexible connections, dust-tight flexible connectors, flexible metal conduit with approved fittings, or flexible cord approved for extra-hard usage and provided with bushed fittings shall be used, except that where dusts are of an electrically conducting nature, flexible metal conduit shall not be used, and flexible cords shall be provided with dust-tight seals at both ends. An additional conductor for grounding shall be provided in the flexible cord unless other acceptable means of grounding is provided. Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type approved for the condition or shall be protected by means of a suitable sheath.

(b) Class II, Division 2. In Class II, Division 2 locations, rigid metal conduit, type MI cable with approved termination fittings, or approved Type MC or ALS cable with approved termination fittings for Class II locations shall be the wiring method employed.

(1) Fittings and Boxes. Fittings and boxes in which taps, joints or terminal connections are made shall be designed to minimize the entrance of dust, and (1) shall be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

(2) Flexible Connections. Where flexible connections are necessary the provisions of Section 502-4(a-2) shall apply.

502-5. Sealing, Class II, Divisions 1 and 2. Where a raceway provides communication between an enclosure which is required to be dust-ignition-proof and one which is not, suitable means shall be provided to prevent the entrance of dust into the dust-ignition-proof enclosure through the raceway. This means may be (1) a permanent and effective seal, (2) a horizontal section not less than 10 feet long in the raceway, or (3) a vertical section of raceway not less than 5 feet long and extending downward from the dust-ignition-proof enclosure. Sealing fittings shall be accessible.

502-6. Switches, Circuit Breakers, Motor Controllers, and Fuses. Switches, circuit breakers, motor controllers and fuses shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, switches, circuit breakers, motor controllers and fuses shall conform to the following:

(1) Type Required. Switches, circuit breakers, motor controllers and fuses, including push buttons, relays and similar devices, which are intended to interrupt current in the normal performance of the function for which they are installed, or which are installed where dusts of an electrically conducting nature may be present, shall be provided with dust-ignition-proof enclosures which, together with the enclosed apparatus in each case, shall be approved as a complete assembly for Class II locations.

This includes service and branch circuit fuses, switches and circuit breakers, motor controllers (including push buttons, pilot switches, relays, and motor overload protective devices), and switches, fuses and circuit breakers for the control and protection of lighting and appliance circuits.

(2) Isolating Switches. Disconnecting and isolating switches containing no fuses and not intended to interrupt current, and which are not installed where dusts may be of an electrically conducting nature, shall be provided with tight metal enclosures which shall be designed to minimize the entrance of dust, and which shall (1) be equipped with telescoping or close fitting covers, or with other effective means to prevent the escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of dust or adjacent combustible material might be ignited.

(3) Metal Dusts. In locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fuses, switches, motor controllers and circuit breakers shall have enclosures specifically approved for such locations.

(b) Class II, Division 2. In Class II, Division 2 locations, enclosures for fuses, switches, circuit breakers and motor controllers including push buttons, relays and similar devices, shall conform to the requirements of Section 502-6(a-2).

502-7. Control Transformers and Resistors. Transformers, solenoids, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, control transformers, solenoids, impedance coils and resistors, and any overcurrent devices or switching mechanisms associated with them shall have dust-ignition-proof enclosures approved for Class II locations. No control transformer, impedance coil or resistor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless provided with an enclosure specifically approved for such locations.

(b) Class II, Division 2. In Class II, Division 2 locations, transformers and resistors shall conform to the following:

(1) Switching Mechanisms. Switching mechanisms (including overcurrent devices) associated with control transformers, solenoids, impedance coils and resistors, shall be provided with enclosures conforming to Section 502-6(a-2).

(2) Coils and Winding. Where not located in the same enclosure with switching mechanisms, control transformers, solenoids and impedance coils shall be provided with tight metal housings without ventilating openings.

(3) Resistors. Resitors and resistance devices shall have dust-ignition-proof enclosures approved for Class II locations, except that where the maximum normal operating temperature of the resistor will not exceed 120°C. (248°F.) nonadjustable resistors and resistors which are part of an automatically timed starting sequence may have enclosures conforming to Section 502-7(b-2).

502-8. Motors and Generators. Motors and generators shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, motors, generators and other rotating electrical machinery shall be totally enclosed not ventilated, totally enclosed pipe ventilated, or totally enclosed fan-cooled, and shall be approved as dust-ignition-proof for Class II locations. Motors, generators or other rotating electrical machinery shall not be installed in locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless such machines are totally enclosed, or totally enclosed fan-cooled, and specifically approved for such locations.

(b) Class II, Division 2. In Class II, Division 2 locations, motors, generators and other rotating electrical machinery shall be totally enclosed not ventilated, totally enclosed pipe ventilated, or totally enclosed fan-cooled, except that in locations where, in the judgment of the code enforcing authority, only moderate accumulations of nonconducting, nonabrasive dust are likely to occur, and where the equipment is readily accessible for routine cleaning and maintenance self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed. Motors, generators or other rotating electrical machinery of partially enclosed or splashproof type shall not be installed in such locations.

502-9. Ventilating Piping. Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gage, or of equally substantial noncombustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against physical damage and against rusting or other corrosive influences. In addition, vent pipes shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, vent pipes, including their connections to motors or to the dust-ignition-proof enclosures for other equipment or apparatus, shall be dust-tight throughout their length. For metal pipes, seams and joints shall be (1) riveted (or bolted) and soldered, (2) welded, or (3) rendered dust-tight by some other equally effective means.

(b) Class II, Division 2. In Class II, Division 2 locations, vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints may be used, and tight-fitting slip joints may be used where some flexibility is necessary as at connections to motors.

502-10. Utilization Equipment, Fixed and Portable. Utilization equipment, fixed and portable, shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, utilization equipment, including electrically heated and motor-driven equipment, shall be dust-ignition-proof approved for Class II locations. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, such equipment shall be specifically approved for such locations.

(b) Class II, Division 2. In Class II, Division 2, locations, utilization equipment, fixed and portable, shall conform to the following:

(1) Heaters. Electrically heated utilization equipment shall be dust-ignition-proof approved for Class II locations.

(2) Motors. Motors of motor-driven utilization equipment shall conform to Section 502-8(b).

(3) Switches, Circuit Breakers and Fuses. Enclosures for switches, circuit breakers, and fuses shall conform to Section 502-6(a-2).

(4) Transformers, Impedance Coils and Resistors. Transformers, solenoids, impedance coils and resistors shall conform to Section 502-7(b).

502-11. Lighting Fixtures. Lamps shall be installed in fixtures which shall conform to the following:

(a) Class II, Division 1. In Class II, Division 1 locations, lighting fixtures for fixed and portable lighting shall conform to the following:

(1) Approved Fixtures. Each fixture shall be dust-ignition-proof and approved for Class II locations, and shall be clearly marked to indicate the maximum wattage of the lamp for which it is approved. In locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fixtures for fixed or portable lighting, and all auxiliary equipment, shall be specifically approved for such locations.

(2) Physical Damage. Each fixture shall be protected against physical damage by a suitable guard or by location.

(3) Pendant Fixtures. Pendant fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose and for the location shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting. Threaded joints shall be provided with set-screws or other effective means to prevent loosening. Where wiring between an outlet box or fitting and a pendant fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used, and suitable seals shall be provided where the cord enters the fixture and the outlet box or fitting. Flexible cord shall not serve as the supporting means for a fixture.

(4) Supports. Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class II locations.

(b) Class II, Division 2. In Class II, Division 2 locations, lighting fixtures shall conform to the following:

(1) Portable Lamps. Portable lamps shall be dust-ignition-proof and approved for Class II locations. They shall be clearly marked to indicate the maximum wattage of lamps for which they are approved.

(2) Fixed Lighting. Lighting fixtures for fixed lighting, when not of a type approved for Class II locations, shall provide enclosures for lamps and lampholders which shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material or hot metal. Each fixture shall be clearly marked to indicate the maximum wattage of lamp which may be used without exceeding a maximum exposed surface temperature of 165°C. (329°F.) under normal conditions of use.

(3) Physical Damage. Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location.

(4) Pendant Fixtures. Pendant fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting. When wiring between an outlet box or fitting and a pendant fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

(5) Supports. Boxes, box assemblies and fittings used for the support of lighting fixtures shall be approved for that purpose.

(6) Electric Discharge Lamps. Starting and control equipment for mercury vapor and fluorescent lamps shall conform to the requirement of Section 502-7(b).

502-12. Flexible Cords, Class II, Divisions 1 and 2. Flexible cords used in Class II locations shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Section 400-13, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) be provided with suitable seals to prevent the entrance of dust where the flexible cord enters boxes or fittings which are required to be dust-ignition-proof.

502-13. Receptacles and Attachment Plugs.

(a) Class II, Division 1. In Class II, Division 1 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord, and shall be dust-ignition-proof approved for Class II locations.

(b) Class II, Division 2. In Class II, Division 2 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be so designed that connection to the supply circuit cannot be made or broken while live parts are exposed.

502-14. Signal, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems. Signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to the following:

Refer to Article 800 for rules governing the installation of communication circuits as defined in Article 100.

(a) Class II, Division 1. In Class II, Division 1 locations, signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to the following:

(1) Wiring Method. Where accidental damage or breakdown of insulation might cause arcs, sparks or high temperatures, rigid metal conduit, or Type MI cable with approved termination fittings shall be the wiring method employed. For conduit the number of conductors shall be limited only by the requirement that the cross-sectional area of all conductors shall not exceed 40 per cent of the area of the raceway. Where limited flexibility is desirable or where exposure to physical damage is not severe, flexible cord approved for extra-hard usage may be used.

(2) Contacts. Switches, circuit breakers, relays, contactors and fuses which may interrupt other than voice currents, and current-breaking contacts for bells, horns, howlers, sirens and other devices in which sparks or arcs may be produced, shall be provided with enclosures approved for the location, unless current-breaking contacts are immersed in oil, or unless the interruption of current occurs within a chamber sealed against the entrance of dust, in which case enclosures may be of general purpose type.

(3) Resistors and Similar Equipment. Resistors, transformers and choke coils which may carry other than voice currents, and rectifiers, thermionic tubes, and other heat generating equipment or apparatus shall be provided with dust-ignition-proof enclosures approved for Class II locations.

4) Rotating Machinery. Motors, generators and other rotating electrical machinery shall conform to Section 502-8(a).

(5) Electrical Conducting Dusts. Where dusts are of an electrically conducting nature, all wiring and equipment shall be approved for Class II locations.

(6) Metal Dusts. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, all apparatus and equipment shall be specifically approved for such conditions.

(b) Class II, Division 2. In Class II, Division 2 locations, signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to the following:

(1) Contacts. Enclosures shall conform to Section 502-14(a-2) or contacts shall have tight metal enclosures designed to minimize the entrance of dust, and shall have telescoping or tight fitting covers and no openings through which, after installation, sparks or burning material might escape.

(2) Transformers and Similar Equipment. The windings and terminal connections of transformers and choke coils shall be provided with tight metal enclosures without ventilating openings.

(3) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, and rectifiers shall conform to Section 502-14 (a-3) except that enclosures for thermionic tubes, nonadjustable resistors or rectifiers for which maximum operating temperature will not exceed 120°C. (248°F.) may be of general purpose type.

(4) Rotating Machinery. Motors, generators and other rotating electrical machinery shall conform to Section 502-8(b).

502-15. Live Parts, Class II, Divisions 1 and 2. There shall be no exposed live parts.

502-16. Grounding, Class II, Divisions 1 and 2. Wiring and equipment shall be grounded in conformity with the following:

(a) Exposed Parts. The exposed noncurrent-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or other utilization equipment, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Article 250 of this Code.

(b) Bonding. The locknut-bushing and double-locknut types of contact shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings, or other approved means shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc., between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in Section 502-4, bonding jumpers with proper fittings shall be provided around such conduit.

(c) Lightning Protection. Each ungrounded service conductor of a wiring system in a Class II location, when supplied from an ungrounded overhead electrical supply system in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

(d) Grounded Service Conductor Bonded to Raceway. Wiring in a Class II location, when supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

(e) Transformer Ground Bonded to Raceway. Wiring in a Class II location, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have an ampacity not less than 1/5 that of the service conductors, and shall in no case be smaller than No. 10 when of soft copper, or No. 12 when of medium or hard-drawn copper.

(f) Multiple Grounds. Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in Section 502-16(d or e) shall not be abandoned while any other grounding connection remains connected to the supply system.

ARTICLE 503 — CLASS III INSTALLATIONS — HAZARDOUS LOCATIONS

503-1. General. The general rules of this Code shall apply to the installation of electrical wiring and apparatus in locations classified as Class III under Section 500-6 except as modified by this Article.

Equipment installed in Class III locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of accumulated fibers or flyings. Organic material which is carbonized or is excessively dry is highly susceptible to spontaneous ignition. In general, maximum surface temperatures under operating conditions shall not exceed 165°C. (329°F.) for equipment which is not subject to overloading, and 120°C. (248°F.) for equipment such as motors, power transformers, etc., which may be overloaded.

503-2. Transformers and Capacitors, Class III, Divisions 1 and 2. Transformers and capacitors shall conform to Section 502-2(b).

503-3. Wiring Methods. Wiring methods shall conform to the following:

(a) Class III, Division 1. In Class III, Division 1 locations, rigid metal conduit or Type MI cable shall be the wiring method employed.

(1) Boxes and Fittings. Fittings and boxes in which taps, joints or terminal connections are made shall (1) be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

(2) Flexible Connections. Where flexible connections are necessary the provisions of Section 502-4(a-2) shall apply.

(b) Class III, Division 2. In Class III, Division 2 locations, the wiring method shall conform to Section 503-3(a), except that in sections, compartments or areas used solely for storage and containing no machinery, open wiring on insulators may be employed when installed to conform to Article 320, but only on condition that protection as required by Section 320-12 be provided where conductors are not run in roof spaces, and well out of reach of sources of physical damage.

503-4. Switches, Circuit Breakers, Motor Controllers and Fuses, Class III, Divisions 1 and 2. Switches, circuit breakers, motor controllers and fuses, including push buttons, relays and similar devices, shall be provided with tight metal enclosures designed to minimize entrance of fibers and flyings, and which shall (1) be equipped with telescoping or close fitting covers, or with other effective means to prevent escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of fibers or flyings or adjacent combustible material might be ignited.

503-5. Control Transformers and Resistors, Class III, Divisions 1 and 2. Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances, shall conform to Section 502-7(b), with the exception that, in Class III, Division 1 locations, when these devices are in the same enclosure with switching devices of such control equipment, and are used only for starting or short time duty, the enclosure shall conform to the requirements of Section 503-4.

503-6. Motors and Generators. Motors and Generators shall conform to the following:

(a) Class III, Division 1. In Class III, Division 1 locations, motors, generators, and other rotating electrical machinery shall be totally enclosed not ventilated, totally enclosed pipe ventilated, or totally enclosed fan-cooled, except that in locations where, in the judgment of the Code enforcing authority, only moderate accumulations of lint and flyings will be likely to collect on, in, or in the vicinity of a rotating electrical machine, and where such machine is readily accessible for routine cleaning and maintenance, self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overload devices), or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed.

(b) Class III, Division 2. In Class III, Division 2 locations, motors, generators, and other rotating electrical machinery shall be totally enclosed not ventilated, totally enclosed pipe ventilated, or totally enclosed fan-cooled.

(c) Partially Enclosed Type, Class III, Divisions 1 and 2. Motors, generators or other rotating electrical machinery of the partially enclosed or splash-proof type shall not be installed in Class III locations.

503-7. Ventilating Piping, Class III, Divisions 1 and 2. Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gage, or of equally substantial noncombustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against physical damage and against rusting or other corrosive influences, and (4) vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of fibers or flyings into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite accumulations of fibers or flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints may be used, and tight fitting slip joints may be used where some flexibility is necessary as at connections to motors.

503-8. Utilization Equipment, Fixed and Portable, Class III, Divisions 1 and 2. Utilization equipment shall conform to the following:

(a) Heaters. Electrically heated utilization equipment shall be approved for Class III locations.

(b) Motors. Motors of motor-driven utilization equipment shall conform to Section 503-6(b). Utilization equipment which may be readily moved from one location to another should conform to requirements for the most hazardous location.

(c) Switches, Circuit Breakers, Motor Controllers and Fuses. Switches, circuit breakers, motor controllers and fuses shall conform to Section 503-4.

503-9. Lighting Fixtures, Class III, Divisions 1 and 2. Lamps shall be installed in fixtures which shall conform to the following:

(a) Fixed Lighting. Lighting fixtures for fixed lighting shall provide enclosures for lamps and lampholders which shall be designed to minimize entrance of fibers and flyings, and to prevent the escape of sparks, burning material or hot metal. Each fixture shall be clearly marked to show wattage of lamp which may be used without exceeding a maximum exposed surface temperature of 165°C. (329°F.) under operating conditions of use.

(b) Physical Damage. A fixture which may be exposed to physical damage shall be protected by a suitable guard.

(c) Pendant Fixtures. Pendant fixtures shall be suspended by stems of threaded rigid conduit or threaded metal tubing of equivalent thickness. For stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(d) Supports. Boxes, box assemblies or fittings used for the support of lighting fixtures shall be of a type approved for the purpose.

(e) Portable Lamps. Portable lamps shall be equipped with handles and protected with substantial guards, and lampholders shall be of unswitched type with no exposed metal parts and without provision for receiving attachment plugs. In all other respects, portable lamps shall conform to Section 503-9(a).

503-10. Flexible Cords, Class III, Divisions 1 and 2. Flexible cords shall conform to Section 502-12.

503-11. Receptacles and Attachment Plugs, Class III, Divisions 1 and 2. Receptacles and attachment plugs shall conform to Section 502-13(b).

503-12. Signal, Alarm, Remote-Control and Local Loud-Speaker Intercommunication Systems, Class III, Divisions 1 and 2. Signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to Section 502-14(a).

503-13. Electric Cranes and Hoists, and Similar Equipment, Class III, Divisions 1 and 2. Where installed for operation over combustible fibers or accumulations of flyings, traveling cranes and hoists for material handling, traveling cleaners for textile machinery, and similar equipment shall conform to the following:

(a) Power supply to contact conductors shall be isolated from all other systems and shall be ungrounded, and shall be equipped with an acceptable recording ground detector which will give an alarm and will automatically de-energize the contact conductors in case of a fault to ground, or with an acceptable ground fault indicator which will give a visual and audible alarm, and maintain the alarm as long as power is supplied to the system and the ground fault remains.

(b) Contact conductors shall be so located or guarded as to be inaccessible to other than authorized persons, and shall be protected against accidental contact with foreign objects.

(c) Current collectors shall be arranged or guarded to confine normal sparking and to prevent escape of sparks or hot particles. To reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor. Reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

(d) Control equipment shall conform to Sections 503-4 and 503-5.

Where the distance of travel permits, current to the crane shall be supplied through flexible cord approved for extra hard usage and equipped with approved type of reel or takeup device.

503-14. Electric Trucks. Electric trucks shall conform to NFPA Standard for the Use, Maintenance and Operation of Industrial Trucks (No. 505).

503-15. Storage-Battery Charging Equipment, Class III, Divisions 1 and 2. Storage-battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials so constructed as to adequately exclude flyings or lint, and shall be well ventilated.

503-16. Live Parts, Class III, Divisions 1 and 2. There shall be no exposed live parts except as provided in Section 503-13.

503-17. Grounding, Class III, Divisions 1 and 2. Wiring and equipment shall be grounded in conformity with Section 502-16.

ARTICLE 510 — HAZARDOUS LOCATIONS — SPECIFIC

510-1. Scope. The provisions of Articles 511 to 517 inclusive shall apply to occupancies or parts of occupancies which are or may be hazardous because of atmospheric concentrations of hazardous gases or vapors, or because of deposits or accumulations of materials which may be readily ignitible. It is the intent to assist Code enforcing authorities in the classification of areas with respect to hazardous conditions which may or may not require construction and equipment conforming to Articles 501 to 503 inclusive, and to set forth such additional special requirements as are applicable to the specific occupancy.

510-2. General. The general rules of this Code shall apply to the installation of electrical wiring and equipment in occupancies within the scope of Articles 511 to 517 inclusive, except as such rules are modified in those articles. Where unusual conditions exist in a specific occupancy, the authority enforcing this Code shall judge with respect to the application of specific rules.

It is recommended that the authority enforcing this Code be familiar with National Fire Protection Association standards applying to occupancies included within the scope of Articles 511 to 517 inclusive.

ARTICLE 511 — COMMERCIAL GARAGES, REPAIR AND STORAGE

511-1. Scope. These occupancies shall include locations used for service and repair operations in connection with self-propelled vehicles (including passenger automobiles, buses, trucks, tractors, etc.) in which volatile flammable liquids or flammable gases are used for fuel or power, and locations in which more than three such vehicles are or may be stored at one time.

For further information regarding classification of garages, refer to the NFPA Standard for Garages (No. 88).

511-2. Hazardous Areas. Classification under Article 500.

(a) For each floor at or above grade, the entire area up to a level 18 inches above the floor shall be considered to be a Class I, Division 2 location.

(b) For each floor below grade, the entire area up to a level 18 inches above the bottom of outside doors or other openings which are at or above grade level shall be considered to be Class I, Division 2 location. Where adequate positive-pressure ventilation is provided, the authority enforcing this Code may judge that the hazardous location extends up to a level of only 18 inches above each such floor.

(c) Any pit or depression below floor level shall be considered to be a Class I, Division 2 location which shall extend up to said floor level, except that any unventilated pit or depression may be judged by the authority enforcing this Code to be a Class I, Division 1 location.

(d) Adjacent areas in which hazardous vapors are not likely to be released such as stock rooms, switchboard rooms and other similar locations, having floors elevated at least 18 inches above adjacent garage floor, or separated therefrom by tight curbs or partitions at least 18 inches high, shall not be classed as hazardous.

511-3. Wiring and Equipment in Hazardous Areas. Within hazardous areas as defined in Section 511-2, wiring and equipment shall conform to applicable provisions of Article 501.

511-4. Sealing. Approved seals conforming to the requirements of Section 501-5 shall be provided, and Section 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous area above the floor if any connections or extensions lead into or through such area.

511-5. Wiring in Spaces Above Hazardous Areas.

(a) All fixed wiring shall be in metallic raceways or shall be Type MI or Type ALS cable. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor, but such raceways shall have no connections leading into or through any hazardous area above the floor. No electrical conductor shall be installed in any cell, header or duct which contains a pipe for steam, water, air, gas, drainage, or other service except electrical.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

(c) For connection of portable lamps, motors or other utilization equipment, flexible cord suitable for the type of service and approved for extra hard usage shall be used.

(d) When a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any utilization equipment supplied.

(e) When a pendant is used to supply a portable lamp or utilization equipment, the female portion of a polarized pin-plug connector or equivalent shall be attached to the lower end of the pendant, and the male portion shall be attached to the cord for the portable. The connector shall be designed to break apart readily in any position, and shall be suspended at a level not less than that specified in Section 511-2. Attachment plug receptacles in fixed position shall be located above the level specified in Section 511-2.

511-6. Equipment Above Hazardous Areas.

(a) Equipment which is less than 12 feet above floor level, and which may produce arcs, sparks or particles of hot metal, such as cutouts, switches, receptacles, charging panels, generators, motors, or other equipment (excluding lamps and lampholders) having make and break or sliding contacts, shall be of totally-enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

(b) Lamps and lampholders for fixed lighting which are located over lanes through which vehicles are commonly driven or which may otherwise be exposed to physical damage, shall be located not less than 12 feet above floor level unless of totally enclosed type or provided with suitable guards, screens or covers to prevent escape of sparks or hot metal particles.

(c) Portable lamps shall be equipped with handle, lampholder, hook and substantial guard attached to the lampholder or handle. All exterior surfaces which might come in contact with battery terminals, wiring terminals, or other objects shall be of nonconducting material or shall be effectively protected with insulation. Lampholders shall be of unswitched type, and shall not provide means for plug-in of attachment plugs. Outer shell shall be of moulded composition or other material approved for the purpose, and metal-shell, lined lampholders, either of switched or unswitched type, shall not be used. Unless the lamp and its cord are supported or arranged in such a manner that they cannot be used in the hazardous areas classified in Section 511-2, they shall be of a type approved for such hazardous locations.

511-7. Battery-Charging Equipment. Battery chargers and their control equipment, and batteries being charged shall not be located within hazardous areas classified in Section 511-2. Tables, racks, trays, and wiring shall, in addition, conform to the provisions of Article 480.

511-8. Electric Vehicle Charging.

(a) Flexible cords used for charging shall be suitable for the type of service and approved for extra hard usage. Their ampacity shall be adequate for the charging current.

(b) Connectors shall have a rating not less than the ampacity of the cord, and in no case less than 50 amperes.

(c) Connectors shall be so designed and installed that they will break apart readily at any position of the charging cable, and live parts shall be guarded from accidental contact. No connector shall be located within a hazardous area defined in Section 511-2.

(d) Where plugs are provided for direct connection to vehicles, the point of connection shall not be within a hazardous area as defined in Section 511-2, and where the cord is suspended from overhead, it shall be so arranged that the lowest point of sag is at least 6 inches above the floor. Where the vehicle is equipped with an approved plug which will readily pull apart, and where an automatic arrangement is provided to pull both cord and plug beyond the range of physical damage, no additional connector is required in the cable or at the outlet.

ARTICLE 512 — RESIDENTIAL STORAGE GARAGES

512-1. Definition. A residential storage garage is a building or room in which not more than three vehicles of the types described in Section 511-1 are or may be stored, but which will not normally be used for other than minor service or repair operations on such stored vehicles.

512-2. At or Above Grade. Where the lowest floor is at or above adjacent ground or driveway level, and where there is at least one outside door at or below floor level, the garage area shall not be classed as a hazardous location.

512-3. Below Grade. Where the lowest floor is below adjacent ground or driveway level, the following shall apply:

(a) The entire area of the garage or of any enclosed space which includes the garage shall be classified as a Class I, Division 2 location up to a level 18 inches above the garage floor. All electrical equipment and wiring within such hazardous location shall conform to applicable provisions of Article 501.

(b) Wiring and equipment above the defined hazardous location shall conform to the requirements of this Code for nonhazardous locations.

(c) Adjacent areas in which hazardous vapors or gases are not likely to be released, and having floors elevated at least 18 inches above the garage floor, or separated therefrom by tight curbs or partitions at least 18 inches high, shall not be classed as hazardous.

ARTICLE 513 — AIRCRAFT HANGARS

513-1. Definition. This occupancy shall include locations used for storage or servicing of aircraft in which gasoline, jet fuels, or other volatile flammable liquids, or flammable gases, are used, but shall not include such locations when used exclusively for aircraft which have never contained such liquids or gases, or which have been drained and properly purged.

513-2. Hazardous Areas. Classification under Article 500.

(a) Any pit or depression below the level of the hangar floor shall be considered to be a Class I, Division 1 location which shall extend up to said floor level.

(b) The entire area of the hangar including any adjacent and communicating areas not suitably cut off from the hangar shall be considered to be a Class I, Division 2 location up to a level 18 inches above the floor.

(c) The area within 5 feet horizontally from aircraft power plants, aircraft fuel tanks or aircraft structures containing fuel shall be considered to be a Class I, Division 2 hazardous location which shall extend upward from the floor to a level 5 feet above the upper surface of wings and of engine enclosures.

(d) Adjacent areas in which hazardous vapors are not likely to be released such as stock rooms, electrical control rooms, and other similar locations, should not be classed as hazardous when adequately ventilated and when effectively cut off from the hangar itself by walls or partitions.

513-3. Wiring and Equipment in Hazardous Areas. All fixed and portable wiring and equipment which is or may be installed or operated within any of the hazardous locations defined in Section 513-2 shall conform to applicable provisions of Article 501. All wiring installed in or under the hangar floor shall conform to the requirements for Class I, Division 1. When such wiring is located in vaults, pits, or ducts, adequate drainage shall be provided, and the wiring shall not be placed within the same compartment with any other service except piped compressed air.

513-4. Wiring Not Within Hazardous Areas.

(a) All fixed wiring in a hangar, but not within a hazardous area as defined in Section 513-2, shall be installed in metallic raceways or shall be Type MI or Type ALS cable, except that wiring in nonhazardous locations as defined in Section 513-2(d) may be of any type recognized in Chapter 3 of this Code.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used. Each such cord shall include a separate grounding conductor.

(c) For portable utilization equipment and lamps, flexible cord suitable for the type of service and approved for extra hard usage shall be used. Each such cord shall include a separate grounding conductor.

(d) Where a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any utilization equipment supplied. Acceptable means shall be provided for maintaining continuity of the grounding conductor between the fixed raceway system and the noncurrent-carrying metallic portions of pendant fixtures, portable lamps, and portable utilization equipment.

513-5. Equipment not Within Hazardous Areas.

(a) In locations other than those described in Section 513-2, equipment which is less than 10 feet above wings and engine enclosures of aircraft and which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make and break or sliding contacts, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles, except that equipment in areas described in Section 513-2(d) may be of general purpose type.

(b) Lampholders of metal shell, fiber-lined types shall not be used for fixed incandescent lighting.

(c) Portable lamps which are or may be used within a hangar shall be approved for Class I locations.

(d) Portable utilization equipment which is or may be used within a hangar shall be of a type suitable for use in Class I, Division 2 locations.

513-6. Stanchions, Rostrums and Docks.

(a) Electric wiring, outlets and equipment (including lamps) on or attached to stanchions, rostrums or docks which are located or likely to be located in a hazardous area as defined in Section 513-2(c) shall conform to the requirements for Class I, Division 2 locations.

(b) Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous area as defined in Section 513-2(c), wiring and equipment shall conform to Sections 513-4 and 513-5, except that such wiring and equipment not more than 18 inches above the floor in any position shall conform to Section 513-6(a). Receptacles and attachment plugs shall be of locking type which will not break apart readily.

(c) Mobile stanchions with electrical equipment conforming to Section 513-6(b) shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

513-7. Sealing. Approved seals shall be provided in conformance with Section 501-5 and Section 501-5(a-3) and 501-5(b-2) and shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous area above the floor when any connections or extensions lead into or through such area.

513-8. Aircraft Electrical Systems. Aircraft electrical systems should be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

513-9. Aircraft Battery — Charging and Equipment.

(a) Aircraft batteries should not be charged when installed in an aircraft located inside or partially inside a hangar.

(b) Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in Section 513-2, and should preferably be located in a separate building or in an area such as described in Section 513-2(d). Mobile chargers shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS." Tables, racks, trays, and wiring shall not be located within a hazardous area, and shall, in addition, conform to the provisions of Article 480.

513-10. External Power Sources for Energizing Aircraft. |

(a) Aircraft energizers shall be so designed and mounted that all electrical equipment and fixed wiring will be at least 18 inches above floor level and shall not be operated in a hazardous area as defined in Section 513-2(c).

(b) Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(c) Aircraft energizers should be equipped with polarized external power plugs and should have automatic controls to isolate the ground power unit electrically from the aircraft in case excessive voltage is generated by the grounding power unit.

(d) Flexible cords for aircraft energizers and ground support equipment shall be approved for the type of service and extra hard usage and shall include a ground conductor.

513-11. Mobile Servicing Equipment with Electrical Components.

(a) Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers, etc.) having electrical wiring and equipment not suitable for Class I, Division 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 18 inches above the floor. Such mobile equipment shall not be operated within the hazardous areas defined in Section 513-2(c) and shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(b) Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra hard usage, and shall include a grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

(c) Equipment not of a type suitable for Class I, Division 2 locations should not be operated in areas where maintenance operations likely to release hazardous vapors are in progress.

513-12. Grounding. All metallic raceways, and all noncurrent-carrying metallic portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

ARTICLE 514 — GASOLINE DISPENSING AND SERVICE STATIONS

514-1. Definitions. This classification shall include locations where gasoline or other volatile flammable liquids or liquefied flammable gases are transferred to the fuel tanks (including auxiliary fuel tanks) of self-propelled vehicles.

Other areas used as lubritoriums, service rooms and repair rooms, and offices, salesrooms, compressor rooms and similar locations shall conform to Articles 510 and 511 with respect to electrical wiring and equipment.

Where the authority enforcing the Code can satisfactorily determine that flammable liquids having a flash point below 100°F such as gasoline will not be handled, he may classify such an area as nonhazardous.

For further information regarding safeguards for gasoline dispensing and service stations see NFPA Flammable and Combustible Liquids Code (No. 30).

514-2. Hazardous Areas.

(a) The space within the dispenser up to 4 feet from its base and the space within 18 inches extending horizontally from the dispenser up to 4 feet from its base shall be considered a Class I, Division 1 location. This classification shall also apply to any space below the dispenser which may contain electrical wiring or equipment.

(b) In an outside location, any area (excluding Class I, Division 1, but including buildings not suitably cut off) within 20 feet horizontally from the exterior enclosure of any dispensing pump shall be considered a Class I, Division 2 location which will extend to a level 18 inches above driveway or ground level.

(c) In an outside location, any area (excluding Class I, Division 1, but including buildings not suitably cut off) within 10 feet horizontally from any tank fill-pipe shall be considered a Class I, Division 2 location which shall extend upward to a level 18 inches above driveway or ground level.

(d) Electrical wiring and equipment, any portion of which is below the surface of areas defined as Class I, Division 1 or Division 2 in 514-2(a), (b), (c) above shall be considered to be within a Class I Division 1 location which shall extend at least to the point of emergence above grade.

(e) The spherical volume within a 3 foot radius from point of discharge of any tank vent-pipe shall be considered a Class I, Division I location and the volume between three foot to five foot radius from point of discharge of a vent shall be considered a Class I, Division 2 location. For any vent that does not discharge upward, the cylindrical volume below both the Division 1 and 2 locations extending to the ground shall be considered a Class I, Division 2 location. The hazardous area shall not extend beyond an unpierced wall.

514-3. Wiring and Equipment Within Hazardous Areas. All electrical equipment and wiring within the hazardous areas defined in Section 514-2 shall conform to applicable provisions of Article 501.

For special requirements for conductor insulation, see Section 501-13.

514-4. Wiring and Equipment Above Hazardous Areas. Wiring and equipment above hazardous areas defined in Section 514-2 shall conform to Sections 511-5 and 511-6.

514-5. Circuit Disconnects. Each circuit leading to or through a dispensing pump shall be provided with a switch or other acceptable means to disconnect simultaneously from the source of supply all conductors of the circuit including the grounded neutral, if any.

514-6. Sealing.

(a) An approved seal shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication therewith. The sealing fitting shall be the first fitting after the conduit emerges from the earth or concrete.

(b) Additional seals shall be provided in conformance with Section 501-5 and Sections 501-5(a-3) and 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

514-7. Grounding. Metallic portions of dispensing pumps, metallic raceways, and all noncurrent-carrying portions of electrical equipment, regardless of voltage, shall be grounded as provided in Article 250.

514-8. Underground wiring shall be installed in rigid metal conduit, or, where buried under not less than 2 feet of earth, may be installed in non-metallic conduit conforming to the requirements of Section 347-2. (d). Where non-metallic conduit is used, an additional grounding conductor shall be included to provide for metallic continuity of the raceway system and for grounding of noncurrent carrying metallic parts of equipment.

ARTICLE 515 — BULK-STORAGE PLANTS

515-1. Definition. This designation shall include locations where gasoline or other volatile flammable liquids are stored in tanks having an aggregate capacity of one carload or more, and from which such products are distributed (usually by tank truck).

515-2. Hazardous Areas.

(a) Pumps, Bleeders, Withdrawal Fittings, Meters and Similar Devices.

(1) Adequately ventilated indoor areas containing pumps, bleeders, withdrawal fittings, meters and similar devices which are located in pipe lines handling flammable liquids under pressure shall be considered as Class I, Division 2 locations within a 5 foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 2 location shall also extend 25 feet horizontally from any surface of these devices and extend upward to 3 feet above floor or grade level.

See Flammable and Combustible Liquids Code, NFPA No. 30, for discussion of factors influencing adequacy of ventilation required to prevent formation of hazardous vapor-air mixtures.

(2) Inadequately ventilated indoor areas containing pumps, bleeders, withdrawal fittings, meters and similar devices which are located in pipe lines handling flammable liquids under pressure shall be considered as Class I, Division 1 location within a 5 foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 1 location shall also extend 25 feet horizontally from any surface of the devices and extend upward to 3 feet above floor or grade level.

(3) Outdoor areas containing pumps, bleeders, withdrawal fittings, meters and similar devices which are located in pipe lines handling flammable liquids under pressure shall be considered as Class I, Division 2 locations within a 3 foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 2 location shall also extend up to 18 inches above grade level within 10 feet horizontally from any surface of the devices.

(b) Transfer of Flammable Liquids to Individual Containers.

(1) In outdoor areas or where positive and reliable mechanical ventilation is provided in indoor areas in which flammable liquids are transferred to individual containers, such areas shall be considered to be a Class I, Division 1 location within 3 feet of the vent or fill opening extending in all directions and a Class I, Division 2 location within the area extending between a 3 foot and 5 foot radius from the vent or fill opening extending in all directions, and including the area within a horizontal radius of 10 feet from the vent or fill opening and extending to a height of 18 inches above floor or grade levels.

See Flammable and Combustible Liquids Code, NFPA No. 30, for discussion of factors influencing adequacy and reliability of mechanical ventilation required to prevent formation of hazardous vapor-air mixtures.

(2) When positive and reliable mechanical ventilation is not provided in indoor areas in which flammable liquids are transferred to individual containers, such areas shall be considered to be a Class I, Division 1 location.

(c) Loading and Unloading of Tank Vehicles and Tank Cars in Outside Locations.

(1) The area extending 3 feet in all directions from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be considered a Class I, Division 1 location.

(2) The area extending between a 3 foot and 5 foot radius from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be considered a Class I, Division 2 location.

(3) The area extending within 3 feet in all directions from a fixed connection used in bottom loading or unloading, loading through a closed dome with atmospheric venting, or loading through a closed dome with a vapor recovery system, shall be considered a Class I Division 2 location. In the case of bottom loading or unloading this classification shall also be applied to the area within a 10 foot radius from point of connection and extending 18 inches above grade.

In deciding upon extent of hazardous area, consideration should be given to the total area within which loading and unloading operation may occur such as racks, platforms, driveways, etc.

(d) Aboveground Tanks.

(1) The area above the roof and within the shell of a floating roof type tank shall be considered a Class I, Division 1 location.

(2) For all types of aboveground tanks the area within 10 feet from the shell, ends and roof of other than a floating roof shall be considered a Class I, Division 2 location. Where dikes are provided the area inside the dike and extending upward to the top of the dike shall be considered to be a Class I, Division 2 location.

(3) The area within 5 feet of a vent opening and extending in all directions shall be considered a Class I, Division 1 location.

(4) The area between 5 and 10 feet of a vent opening and extending in all directions shall be considered a Class I, Division 2 location.

For underground tanks see Article 514.

(e) Pits.

(1) Any pit or depression, any part of which lies within a Division 1 or Division 2 location as defined herein, shall be considered a Class I, Division 1 location unless provided with positive and reliable mechanical ventilation.

(2) Any such areas when provided with positive and reliable mechanical ventilation shall be considered a Class I, Division 2 location.

See .Flammable and Combustible Liquids Code, NFPA No. 30, for discussion of factors pertaining to positive and reliable mechanical ventilation required to prefent formulation of hazardous vapor-air mixtures.

(3) Any pit or depression not within a Division 1 or Division 2 location as defined herein, but which contains piping, valves or fittings shall be classified as a Class I, Division 2 location.

(f) Storage and Repair Garages for Tank Vehicles shall be considered to be a Class I, Division 2 location up to 18 inches above floor or grade level unless in the judgment of the authority enforcing this Code conditions warrant more severe classification or a greater extent of the hazardous area.

(g) Office Buildings, Boiler Rooms and Other Similar Locations which are outside the limits of hazardous areas as defined herein, and which are not used for handling or storage of volatile flammable liquids or containers for such liquids, shall not be considered to be hazardous locations.

515-3. Wiring and Equipment Within Hazardous Areas. All electrical wiring and equipment within the hazardous areas defined in Section 515-2 shall conform to applicable provisions of Article 501.

515-4. Wiring and Equipment Above Hazardous Areas. All fixed wiring above hazardous areas shall be in metallic raceways or shall be Type ALS cable. Fixed equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make and break or sliding contacts, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles. Portable lamps or utilization equipment, and their flexible cords shall conform to the provisions of Article 501 for the class of location above which they are connected or used.

515-5. Underground Wiring.

(a) Underground wiring shall be installed in rigid metal conduit, or, where buried under not less than 2 feet of earth, may be installed in nonmetallic conduit or duct, or in the form of cable approved for the purpose. Where cable is used, it shall be enclosed in rigid metal conduit from the point of lowest buried cable level to the point of connection to the aboveground raceway.

(b) Conductor insulation shall conform to Section 501-13 of Article 501.

(c) Where cable with nonmetallic sheath or nonmetallic conduit is used, an additional grounding conductor shall be included to provide for metallic continuity of the raceway system and for grounding of noncurrent-carrying metallic parts of equipment.

515-6. Sealing. Approved seals shall be provided in conformance with Section 501-5 and Sections 501-5(a-3) and 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Buried raceways under defined hazardous areas shall be considered to be within such areas.

515-7. Gasoline Dispensing. Where gasoline dispensing is carried on in conjunction with bulk station operations, applicable provisions of Article 514 shall apply.

515-8. Grounding. All metallic raceways, and all noncurrent-carrying metallic portions of electrical equipment shall be grounded as provided in Article 250.

ARTICLE 516 — FINISHING PROCESSES

516-1. Definition. This Article shall apply to locations where paints, lacquers or other flammable finishes are regularly or frequently applied by spraying, dipping, brushing or by other means, and where volatile flammable solvents or thinners are used or where readily ignitible deposits or residues from such paints, lacquers or finishes may occur.

For further information regarding safeguards for finishing processes, see the NFPA Standard for Spray Finishing Using Flammable Materials (No. 33) and the NFPA Standard for Dip Tanks Containing Flammable or Combustible Liquids (No. 34).

516-2. Hazardous Areas. Classification with respect to flammable vapors. For deposits and residues, see Section 516-3.

(a) The interiors of spray booths and their exhaust ducts, all space within 20 feet horizontally in any direction from spraying operations more extensive than touch-up spraying and not conducted within spray booths, all space within 20 feet horizontally in any direction from dip tanks and their drain boards, and all other spaces where hazardous concentrations of flammable vapors are likely to occur, shall be considered to be Class I, Division 1 locations.

(b) All space within 20 feet horizontally in any direction from the open face of a spray booth, and all space within the room but beyond the limits for Class I, Division 1 as defined in Section 516-2(a) for extensive open spraying, for dip tanks and drain boards and for other hazardous operations, shall be considered to be Class I, Division 2 locations unless the authority enforcing this Code judges otherwise.

(c) Adjacent areas which are cut off from the defined hazardous areas by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classed as nonhazardous unless the Code enforcing authority judges otherwise.

(d) Drying and baking areas provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to de-energize all electric equipment (other than equipment approved for Class I locations) in case the ventilating equipment is inoperative, may be classed as nonhazardous when the Code-enforcing authority so judges.

516-3. Wiring and Equipment in Hazardous Areas.

(a) All electrical wiring and equipment within the hazardous areas defined in Section 516-2 shall conform to applicable provisions of Article 501.

(b) Unless approved for both readily ignitible deposits and the flammable vapor location, no electrical equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitible deposits or residues, except that wiring in rigid conduit or in threaded boxes or fittings containing no taps, splices or terminal connections may be installed in such locations. Type MI cable without fittings or boxes may be used.

(c) Illumination of readily ignitible areas through panels of glass or other transparent or translucent material is permissible only where: (a) fixed lighting units are used as the source of illumination, (b) the panel effectively isolates the hazardous area from the area in which the lighting unit is located, (c) the lighting unit is approved for its specific location, (d) the panel is of a material or is so protected that breakage will be unlikely and (e) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

(d) Portable electric lamps or other utilization equipment shall not be used within a hazardous area during operation of the finishing process. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class I locations, and all exposed metal parts shall be effectively grounded.

(e) Electrostatic spraying or detearing equipment shall be installed and used only as provided in Section 516-4.

For more details, see NFPA No. 33.

516-4. Fixed Electrostatic Equipment. Where electrostatic spraying and detearing equipment is installed, such equipment shall be of approved type, and shall conform to the following requirements.

(a) No transformers, power packs, control apparatus, or other electrical portion of the equipment (except high voltage grids and their connections) shall be installed in any of the hazardous areas defined in Section 516-2 unless of a type approved for the location.

(b) High voltage grids or electrodes shall be located in suitable noncombustible booths or enclosures provided with adequate mechanical ventilation, shall be rigidly supported and of substantial construction, and shall be effectively insulated from ground by means of nonporous noncombustible insulators.

(c) High voltage leads shall be effectively and permanently supported on suitable insulators, shall be effectively guarded against accidental contact or grounding, and shall be provided with automatic means for discharging any residual charge to ground when the supply voltage is interrupted.

(d) Goods being processed shall be supported on conveyors in such a manner that minimum clearance between goods and high voltage grids or conductors cannot be less than twice the sparking distance. A conspicuous sign indicating the sparking distance shall be permanently posted near the equipment.

(e) Approved automatic controls which will operate without time delay to disconnect the power supply and to signal the operator in case of (a) stoppage of ventilating fans or failure of ventilating equipment from any cause, (b) stoppage of the conveyor carrying goods through the high voltage field, (c) occurrence of a ground or of an imminent ground at any point on the high voltage system, or (d) reduction of clearance below that specified in Section 516-4(d).

(f) Adequate fencing, railings or guards which are electrically conducting and effectively grounded shall be provided for safe isolation of the process, and signs shall be permanently posted designating the process zone as dangerous because of high voltage.

516-5. Electrostatic Hand Spraying Equipment. Electrostatic hand spray apparatus and devices used in connection with paint spraying operations shall be of approved types and shall conform to the following requirements:

(a) The equipment shall be so designed that the maximum surface temperature of the equipment in the spraying area can not exceed 150°F. under any condition. The high voltage circuits shall be designed so as to be intrinsically safe and not produce a spark of sufficient intensity to ignite any vapor-air mixtures nor result in appreciable shock hazard upon coming in contact with a grounded object. The electrostatically charged exposed elements of the hand gun shall be capable of being energized only by a switch which also controls the paint supply.

(b) Transformers, power packs, control apparatus, and all other electrical portion of the equipment, with the exception of the hand gun itself and its connections to the power supply, shall be located outside of the hazardous area.

(c) The handle of the spraying gun shall be electrically connected to ground by a metallic connection and be so constructed that the operator in normal operating position is in intimate electrical contact with the grounded handle. This requirement is to prevent build-up of a static charge on the operator's body.

(d) All electrically conductive objects in the spraying area shall be adequately grounded. This requirement shall apply to paint containers, wash cans and any other objects or devices in the area. The equipment shall carry a prominent permanently installed warning regarding the necessity for this grounding feature.

(e) Objects being painted shall be maintained in metallic contact with the conveyor or other grounded support. Hooks shall be regularly cleaned to insure this contact and areas of contact shall be sharp points or knife edges where possible. Points of support of the object shall be concealed from random spray where feasible and where the objects being sprayed are supported from a conveyor, the point of attachment to the conveyor shall be so located as to not collect spray material during normal operation.

(f) The spraying operation shall take place within a spray area which is adequately ventilated to remove solvent vapors released from the operation. The electrical equipment shall be so interlocked with the ventilation of spraying area that the equipment cannot be operated unless the ventilation fans are in operation.

516-6. Wiring and Equipment Above Hazardous Areas.

(a) All fixed wiring above hazardous areas shall be in metallic raceways or shall be Type MI cable or Type ALS cable. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor of a hazardous area, but such raceways shall have no connections leading into or through the hazardous area above the floor unless suitable seals are provided. No electrical conductor shall be installed in any cell, header or duct which contains a pipe for steam, water, air, gas, drainage, or for other service except electrical.

(b) Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make and break or sliding contacts, where installed above a hazardous area or above an area where freshly finished goods are handled, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

516-7. Grounding. All metallic raceways, and all noncurrent-carrying metallic portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

ARTICLE 517 — FLAMMABLE ANESTHETICS

517-1. Definitions.

(a) Flammable anesthetics are gases or vapors such as cyclopropane, divinyl ether, ethyl chloride, ethyl ether, and ethylene, which may form flammable or explosive mixtures with air, oxygen, or nitrous oxide.

(b) For the purpose of this Article, anesthetizing locations are areas in hospitals in which flammable anesthetics are or may be administered to patients. Such locations will include operating rooms, delivery rooms and anesthesia rooms, and will also include any corridors, utility rooms or other areas which are or may be used for administering flammable anesthetics to patients. Recovery rooms are not classed as anesthetizing locations unless used for administering flammable anesthetics.

For further information regarding safeguards for hospital operating rooms, see the NFPA Code for the Use of Flammable Anesthetics (No. 56).

517-2. Hazardous Areas.

(a) Any room or space in which flammable anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location throughout.

(b) In an anesthetizing location as defined in Section 517-1, the entire area shall be considered to be a Class I, Division 1 location which shall extend upward to a level 5 feet above the floor.

517-3. Wiring and Equipment Within Hazardous Areas.

(a) In hazardous areas as defined in Section 517-2, all fixed wiring and equipment, and all portable equipment, including lamps and other utilization equipment, operating at more than 8 volts between conductors, shall conform to the requirements of Sections 501-1 to 501-15 inclusive and of Sections 501-16(a and b) for Class I, Division 1 locations, and all such equipment shall be specifically approved for the hazardous atmospheres involved.

(b) Where a box, fitting or enclosure is partially but not entirely within a hazardous area, the hazardous area shall be considered to be extended to include the entire box, fitting or enclosure.

(c) Flexible cords which are or may be used in hazardous areas for connection to portable utilization equipment, including lamps operating at more than 8 volts between conductors shall be of a type approved for extra hard usage, shall be of ample length, and shall include an additional conductor for grounding. A storage device for the flexible cord shall be provided, and shall not subject the cord to bending at a radius of less than 3 inches.

(d) Receptacles and attachment plugs shall be of the type with provision for connection of the grounding conductor, and where located within a hazardous area, shall be approved for Class I location. Single phase, 125 volt receptacles and attachment plugs shall be of the type recognized in Section 2438 of NFPA Code for the Use of Flammable Anesthetics (No. 56).

517-4. Wiring and Equipment Above Hazardous Areas.

(a) Wiring above a hazardous area as defined in Section 517-2(b) shall be installed in metal raceways or shall be Type MI cable or Type ALS cable.

(b) Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting less than 8 feet above the floor, cutouts, switches, receptacles, generators, motors, or other equipment having make and break or sliding contacts, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

(c) Surgical and other lighting fixtures shall conform to Section 501-9(b), except that surface temperature limitations set forth in Section 501-9(b-2) shall not apply, and except that integral or pendant switches which are located above and cannot be lowered into the hazardous area need not be explosion-proof.

517-5. Sealing. Approved seals shall be provided in conformance with Section 501-5, and 501-5(a-3) and shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

Exception. Seals may be located within 18 inches of the point at which a conduit emerges from a wall forming the boundary of an anesthetizing location if all of the following conditions are met.

(1) The junction box switch or receptacle contains a seal-off device between the arcing contacts and the conduit.

(2) The conduit is continuous (without coupling or fitting) between the junction box and the sealing fitting within 18 inches of the point where the conduit emerges from the wall.

517-6. Circuits in Anesthetizing Locations.

(a) Except as provided in Section 517-6(e), each circuit within or partially within an anesthetizing location as defined in Section 517-1(b) shall be controlled by a switch having a disconnecting pole in each circuit conductor, and shall be supplied from an ungrounded distribution system which shall be isolated from any distribution system supplying areas other than anesthetizing locations. Such isolation may be obtained by means of one or more transformers having no electrical connection between primary and secondary windings, by means of motor generator sets, or by means of suitably isolated batteries.

(b) Circuits supplying primaries of isolating transformers shall operate at not more than 300 volts between conductors, and shall be provided with proper overcurrent protection. Secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor. Circuits supplied from batteries or from generators or motor-generator sets shall be ungrounded, and shall be protected against overcurrent in the same manner as transformer secondary circuits.

(c) Transformers, motor-generator sets, batteries and battery chargers, together with their overcurrent devices shall be installed in nonhazardous locations, and shall conform to the requirements of this Code for such locations.

(d) In addition to the usual control and protective devices, the ungrounded system shall be provided with an approved ground contact indicator so arranged that a green signal lamp conspicuously visible to persons in the anesthetizing location remains lighted while the system is isolated from ground. An adjacent red signal lamp and an audible warning signal shall be energized when any conductor of the system becomes grounded through a resistance or a capacitive reactance of any value up to at least 60,000 ohms. The current through the ground indicator to the ground shall not exceed 2 milliamperes. The indicator and associated signals shall not be installed within a hazardous area.

For maintenance tests of the ground indicator, see Section 3422 of the NFPA Code for the Use of Flammable Anesthetics (No. 56).

(e) Branch circuits supplying only fixed lighting fixtures above the hazardous location other than surgical lighting fixtures or supplying only approved permanently installed X-ray equipment which complies with Section 2434 of the NFPA Code for the Use of Flammable Anesthetics (No. 56) may be supplied by a conventional grounded system, provided: (a) wiring for grounded and ungrounded circuits does not occupy the same raceways; (b) the lighting fixtures and the X-ray equipment (except the enclosed X-ray tube and the metal-enclosed high voltage leads to the tube) are located at least eight feet above the floor or outside the anesthetizing location; and (c) switches for the grounded circuits are located outside of the anesthetizing location.

NOTE: Remote control stations for remote control switches may be installed in the anesthetizing location if the remote control circuit is energized from the ungrounded distribution system.

517-7. Low Voltage Equipment and Instruments.

(a) Electrical apparatus and equipment used within a hazardous area, and which has exposed current-carrying elements or which is frequently in contact with the bodies of persons, shall be designed to operate at 8 volts or less unless it is entirely surrounded by a metallic casing or sheath. Power supply shall be ungrounded, and shall be electrically isolated from all circuits of higher voltage.

(b) Where a low voltage unit receives current from an individual transformer located within a hazardous area, the flexible cord shall conform to Section 517-3(d), the core and case of the transformer shall be effectively grounded, and the transformer shall be approved for Class I locations.

(c) Where low voltage units within a hazardous area are supplied with current from a common source, such as a transformer, motor-generator set, or storage battery, such common source shall be installed in a nonhazardous location. Where located or used within a hazardous area, receptacles and attachment plugs shall be approved for Class I locations. Plugs shall be so designed that they cannot be inserted into receptacles for higher voltage. Flexible cords shall be of adequate length and ampacity, and shall be approved for extra hard usage. An extra conductor for grounding is not required.

(d) Low voltage equipment and wiring (including flexible cords) shall be protected from dangerous overcurrents by suitable overcurrent devices or by inherent current limiting characteristics of the source of supply. Overcurrent devices shall not be installed in a hazardous area.

(e) Resistance or impedance devices may be used to control low voltage units but shall not be used to limit maximum input voltage. Where a low voltage unit includes a switch or other make and break or sliding contact, or where it includes a resistor or resistance device which may under any operating condition reach a surface temperature exceeding eighty per cent (80%) of the lowest ignition temperature in degrees Centigrade (as determined by ASTM test procedure — Designation D286-30) of the gases or vapors that may be present, the unit shall be of a type approved for Class I locations.

517-8. Other Equipment.

(a) Suction, pressure, or insufflation equipment involving electrical elements, and located or used within a hazardous area shall be approved for Class I locations.

(b) X-ray equipment installed or operated in an anesthetizing location as defined in Section 517-1(b) shall be provided with approved means for preventing accumulation of electrostatic charges. All control devices, switches, relays, meters, and transformers shall be totally enclosed, and where installed or operated within a hazardous area, shall be approved for Class I locations. High voltage wiring shall be effectively insulated from ground and adequately guarded against accidental contact.

(c) Equipment for generating high frequency currents or voltages used in electrocautery, diathermy, television, etc., where installed or used in an anesthetizing location, shall conform to Sections 517-3 and 517-4.

517-9. Grounding. In any hazardous area, all metallic raceways, and all noncurrent-carrying metallic portions of fixed or portable equipment (except equipment operating at not more than 8 volts between conductors) shall be grounded as provided in Sections 501-16(a and b).

ARTICLE 520—THEATERS AND ASSEMBLY HALLS

A. General

520-1. Scope. The requirements of this Article shall apply to all buildings, or part of a building, designed, intended, or used for dramatic, operatic, motion-picture or other shows, and night clubs, dance halls, armories, sporting arenas, bowling alleys, public auditoriums, television studios and like buildings used for public asssembly.

520-2. Motion-Picture Projectors. Motion-picture equipment and its installation and use shall comply with Article 540.

520-3. Sound Reproduction. Sound-reproducing equipment and its installation shall comply with Article 640.

520-4. Wiring Method. The wiring method shall be metal raceways, Type ALS cable or Type MI cable except as follows:

Exception No. 1. As provided in Article 640, Sound Reproduction, in Article 800, Communication Circuits, and in Article 725 for Class 2 Remote Control and Signal Circuits.

Exception No. 2. Where the area intended for public assembly has a capacity of less than 200 persons, Type AC metal-clad cable as provided in Article 334 may be used, or for concealed work, concealed knob-and-tube work or nonmetallic sheathed cable as provided in Articles 324 and 336 may also be used.

For determination of population capacity, refer to Dept. of Public Safety B-1 Regulation.

Exception No. 3. The wiring for stage set lighting and stage effects and other wiring which is not fixed as to location shall be done with approved portable cables and approved flexible cords.

520-5. Number of Conductors in Raceway. The number of conductors permitted in any metal conduit or electrical metallic tubing for border or stage pocket circuits or for remote control conductors shall not exceed that shown in Table 1 of Chapter 9. In the case of auxiliary gutters or wireways, the sum of the cross-sectional areas of all contained conductors at any cross-section shall not exceed 20 per cent of the interior cross-sectional area of the gutter or wireway.

520-6. Enclosing and Guarding Live Parts. Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects. All switches shall be of the externally operable type. Rheostats shall be placed in approved cases or cabinets which enclose all live parts, having only the operating handles exposed.

B. Fixed Stage Switchboard

520-21. Dead Front. Stage switchboards shall be of the dead-front type.

520-22. Guarding Back of Switchboard. Stage switchboards having exposed live parts on the back of such boards shall be enclosed by the building walls, wire mesh grills, or by other approved methods. The entrance to this enclosure shall be by means of a self-closing door.

520-23. Control and Overcurrent Protection of Receptacle Circuits. Means shall be provided at the stage switchboard for the control and individual overcurrent protection of branch circuits to stage and gallery receptacles used for portable stage equipment.

520-24. Metal Hood. A stage switchboard that is not completely enclosed dead-front and dead-rear or recessed into a wall shall be provided with a metal hood extending the full length of the board to protect all equipment on the board from falling objects.

520-25. Dimmers. Dimmers shall conform to the following:

(a) Disconnection and Overcurrent Protection. Where dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection not greater than 125 per cent of the dimmer rating, and shall be disconnected from all ungrounded conductors when the master or individual switch or circuit-breaker supplying such dimmer is in the open position.

(b) Resistance or Reactor Type Dimmers. Resistance or series reactor type dimmers may be placed in either the grounded or the ungrounded conductor of the circuit. Where designed to open either the supply circuit to the dimmer or the circuit controlled by it, the dimmer shall then comply with Section 380-1.

The resistance or reactor type dimmers shall be placed in the grounded neutral conductor of the circuit provided they do not open the circuit.

(c) Auto-Transformer Type Dimmers. The circuit supplying an auto-transformer type dimmer shall not exceed 150 volts between conductors. The grounded conductor shall be common to the input and output circuits. See Section 200-4.

C. Stage Equipment — Fixed

520-41. Circuit Loads. Footlights, border lights, and proscenium side lights shall be so arranged that no branch circuit supplying such equipment will carry a load exceeding 20 amperes; provided that where heavy-duty lampholders only are used, such circuits may conform to the provisions of Article 210 for circuits supplying heavy-duty lampholders.

520-42. Conductor Insulation. Foot, border, proscenium, or portable strip light fixtures shall be wired with conductors having insulation suitable for the temperatures at which the conductors will be operated and not less than 125 °C (257°F). See Table 310-2(a).

520-43. Footlights.

(a) Where metal trough construction is employed for footlights, the trough containing the circuit conductors shall be made of sheet metal not lighter than No. 20 USS gage (.0359 inch in thickness) treated to prevent oxidation. Lampholder terminals shall be kept at least ½ inch from the metal of the trough. The circuit conductors shall be soldered to the lampholder terminals.

(b) Where the metal trough construction specified in Section 520-43(a) is not used, footlights shall consist of individual outlets with lampholders, wired with rigid or flexible metal conduit, Type ALS cable or Type MI cable. The circuit conductors shall be soldered to the lampholder terminals. Disappearing footlights shall be so arranged that the current supply shall be automatically disconnected when the footlights are replaced in the recess designed therefor.

520-44. Borders and Proscenium Sidelights.

(a) Borders and proscenium sidelights shall be constructed as prescribed in Section 520-43, shall be suitably stayed and supported, and shall be so designed that the flanges of the reflectors or other adequate guards will protect the lamps from mechanical injury and from accidental contact with scenery or other combustible material.

(b) Cables for Border Lights. Cables for supply to border lights shall be types S, SO, or ST flexible cord. See Table 400-11. The cables shall be suitably supported. Such cables shall be employed only where flexible conductors are necessary.

520-45. Receptacles. Receptacles intended for the supply of arc lamps shall have not less than 50 amperes capacity and shall be supplied by conductors not smaller than No. 6. Receptacles intended for the supply of incandescent lamps shall have not less than 20 amperes capacity and shall be supplied by conductors not smaller than No. 12. Plugs for arc and incandescent receptacles shall not be interchangeable.

520-46. Stage Pockets. Receptacles intended for the connection of portable stage lighting equipment shall be mounted in suitable pockets or enclosures, and shall comply with the requirements of Section 520-45.

520-47. Lamps in Scene Docks. Lamps installed in scene docks shall be so located and guarded as to be free from mechanical injury and provide an air space of not less than 2 inches between such lamps and any combustible material.

520-48. Curtain Motors. Curtain motors having brushes or sliding contacts shall comply with one of the following conditions:

(a) Be of the totally enclosed, enclosed-fan-cooled, or enclosed-pipe-ventilated types.

(b) Be enclosed in separate rooms or housings built of noncombustible materials so constructed as to exclude flyings or lint, and properly ventilated from a source of clean air.

(c) Have brush or sliding-contact end of motor enclosed by solid metal covers.

(d) Have brushes or sliding contacts enclosed in substantial, tight, metal housings.

(e) Have the upper half of brush or sliding-contact end of the motor enclosed by a wire screen or perforated metal and the lower half enclosed by solid metal covers.

(f) Have wire screens or perforated metal placed at the commutator or brush ends. No dimension of any opening in the wire screen or perforated metal shall exceed .05 inch, regardless of the shape of the opening and of the material used.

520-49. Flue-Damper Control. Where stage flue dampers are released by an electrical device, the circuit operating the latter shall be normally closed and shall be controlled by at least two externally operable switches, one switch being placed at the electrician's station and the other where designated by the inspection authority. The device shall be designed for the full voltage of the circuit to which it is connected, no resistance being inserted. The device shall be located in the loft above the scenery and shall be enclosed in a suitable iron box having a tight, self-closing door.

D. Portable Switchboards on Stage

520-51. Supply. Portable switchboards shall be supplied only from outlets especially provided for this purpose. Such outlets shall include externally operable, enclosed fused switches or circuit breakers mounted on the stage wall or at the switchboard in locations readily accessible from the stage floor.

520-52. Overcurrent Protection. Circuits from portable switchboards directly supplying equipment containing incandescent lamps of not over 300 watts shall be protected by overcurrent devices having a rating or setting of not more than 20 amperes. Circuits for lampholders over 300 watts may be used where overcurrent protection conforms to the provisions of Article 210. Other circuits shall be provided with overcurrent devices with a rating or setting not higher than the current required for the connected load.

520-53. Construction. Portable switchboards for use on stages shall comply with the following:

(a) Enclosure. Portable switchboards shall be placed within an enclosure of substantial construction which may be so arranged that the enclosure is open during operation. Enclosures of wood shall be completely lined with sheet metal of not less than No. 24 USS gage (.0239 inch), and shall be well galvanized, enamelled, or otherwise properly coated to prevent corrosion or be of a corrosion-resistant material.

(b) Live Parts. Except as provided for dimmer face plates in Section 520-53(e), there shall be no exposed live parts within the enclosure.

(c) Switches and Circuit Breakers. All switches and circuit breakers shall be of the externally operable, enclosed type.

(d) Circuit Protection. Overcurrent devices shall be provided in each ungrounded conductor of every circuit supplied through the switchboard. Enclosures shall be provided for all overcurrent devices in addition to the switchboard enclosure.

(e) Dimmers. The terminals of dimmers shall be provided with enclosures, and dimmer face plates shall be so arranged that accidental contact cannot be readily made with the face-plate contacts.

(f) Interior Conductors. All conductors within the switchboard enclosure shall be stranded and, except for cables feeding to or from the switchboard, shall be asbestos-covered type AA or other types approved for a maximum operating temperature of 200°C (392°F). Each conductor shall have an ampacity at least equal to the rating of the circuit breaker, switch or fuse which it supplies, except for conductors for incandescent lamp circuits having overcurrent protection not exceeding 20 amperes. Conductors shall be enclosed in metal troughs or securely fastened in position and shall be bushed where they pass through metal.

(g) Pilot Light. A pilot light shall be provided within the enclosure and shall be so connected to the circuit supplying the board that the opening of the master switch will not cut off the supply to the lamp. This lamp shall be on an independent circuit having overcurrent protection of a rating or setting of not more than 15 amperes.

(h) Supply Connections. The supply to a portable switchboard shall be by means of flexible cord (types S, SO or ST) terminating within the switchboard enclosure or in an externally operable fused master switch or circuit breaker. The supply cable shall have sufficient ampacity to carry the total load on the switchboard and shall be protected by overcurrent devices.

(i) Cable Arrangement. Cables shall be protected by bushings where they pass through enclosures and shall be so arranged that tension on the cable will not be transmitted to the connections.

(j) Terminals. Terminals to which stage cables are connected shall be so located as to permit convenient access to the terminals. At terminals not provided with approved pressure connectors the following construction shall be employed:

(1) For conductors of No. 10 or larger, solder lugs shall be used.

(2) For conductors smaller than No. 10, the strands shall be soldered together where connected to clamps or binding screws not specifically approved as pressure connectors.

E. Stage Equipment — Portable

520-61. Arc Lamps. The construction of arc lamps shall be approved by the authorities having jurisdiction.

520-62. Portable Plugging Boxes. Portable plugging boxes shall conform to the following:

(a) Enclosure. The construction shall be such that no current-carrying part will be exposed.

(b) Receptacles and Overcurrent Protection. Each receptacle shall have a rating of not less than 30 amperes, and shall have overcurrent protection which shall be installed in an enclosure equipped with self-closing doors.

(c) Busbars and Terminals. Busbars shall have an ampacity equal to the sum of the ampere ratings of all the receptacles. Lugs shall be provided for the connection of the master cable.

520-63. Lights on Scenery.

(a) Brackets on scenery shall be wired internally and the fixture stem shall be carried through to the back of the scenery where a bushing shall be placed on the end of the stem, except that externally wired brackets or other fixtures may be used when wired with cords designed for hard usage which shall extend through scenery and without joint or splice in canopy of fixture back and terminate in an approved type stage connector located within 18 inches of the fixture, unless such location is impractical.

(b) Fixtures shall be securely fastened in place.

520-64. Portable Strips. Portable strips shall be constructed in accordance with the requirements for border lights and proscenium side lights in Section 520-44(a). The supply cable shall be protected by bushings where it passes through metal and shall be so arranged that tension on the cable will not be transmitted to the connections. See Section 520-42 for wiring of portable strips.

520-65. Festoons. Joints in festoon wiring shall be staggered where practicable. Lamps enclosed in lanterns or similar devices of combustible material shall be equipped with approved guards.

520-66. Special Effects. Electrical devices used for simulating lightning, waterfalls, and the like, shall be so constructed and located that flames, sparks, or hot particles cannot come in contact with combustible material.

520-67. Cable Connectors. Cable connectors for flexible conductors shall be so constructed that tension on the cord or cable will not be transmitted to the connections. See Section 400-9. The female half of the connector shall be attached to the line end of the cord or cable.

520-68. Conductors for Portables. Flexible conductors used to supply portable stage equipment shall be Types S, SO or ST, except that reinforced cord may be used to supply stand lamps where the cord is not liable to severe physical damage and is protected by an overcurrent protection rated at not over 20 amperes.

F. Dressing Rooms

520-71. Pendant Lampholders. Pendant lampholders shall not be installed in dressing rooms.

520-72. Lamp Guards. All incandescent lamps in dressing rooms, where less than 8 feet from the floor, shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed or locked in place.

520-73. Switches Required. All lights and receptacles in dressing rooms shall be controlled by wall switches installed in the dressing rooms. Each switch controlling receptacles shall be provided with a pilot light to indicate when the receptacle or receptacles are energized.

G. Grounding

520-81. Grounding. All metal raceways shall be grounded. The metal frames and enclosures of equipment including border lights shall be grounded, except the frames and enclosures of portable equipment on grounded circuits operating at not over 150 volts to ground and not within reach of grounded surfaces. Grounding, when employed, shall be done in the manner specified in Article 250.

ARTICLE 530 — MOTION-PICTURE STUDIOS AND SIMILAR LOCATIONS

A. General

530-1. Scope. The requirements of this Article shall apply to television studios (except as covered in Section 520-1), motion-picture studios, exchange, factory, laboratory, stage, or a portion of the building in which motion-picture films more than ⅞ inch in width are manufactured, exposed, developed, printed, cut, edited, rewound, repaired or stored.

For the purpose of this Article, a motion-picture studio is one in which photographic film is used to record action. A television studio shall mean one which employs the use of electronic cameras only.

For recommendations for protection against cellulose nitrate film hazards refer to NFPA Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film (No. 40).

B. Stage or Set

530-11. Permanent Wiring. The permanent wiring shall be in approved metal raceways Type ALS cable or Type MI cable.

Exception. Communication circuits, and sound recording and reproducing equipment may be wired as permitted by the articles covering those installations. (See Articles 640 and 800).

530-12. Portable Wiring. The wiring for stage set lighting and stage effects, and other wiring which is not fixed as to location, shall be done with approved portable cables and approved flexible cords. This requirement shall not apply to portable lamps or other electrical equipment used as properties in a motion picture set, on a studio stage or lot, or on location.

530-13. Stage Lighting and Effects Control. Switches used for studio stage set lighting and effects (on the stages and lots and on location) shall be of the externally operable type. When contactors are used as the disconnecting means for fuses, an individual externally operable type switch (such as a tumbler switch) for the control of each contactor, shall be located at a distance of not more than six feet from the contactor, in addition to remote control switches.

Exception. A single externally operable switch may be used to simultaneously disconnect all the contactors on any one location board, where located at a distance of not more than 6 feet from the location board.

530-14. Plugging Boxes. Each receptacle of plugging boxes shall have an ampacity of not less than 30 amperes.

530-15. Enclosing and Guarding Live Parts.

(a) Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects.

(b) All switches shall be of the externally operable type.

(c) Rheostats shall be placed in approved cases or cabinets which enclose all live parts, having only the operating handles exposed.

(d) Current-carrying parts of "bull-switches," "location boards," "spiders," and plugging boxes shall be so enclosed, guarded, or located that persons cannot accidentally come into contact with them or bring conducting materials into contact with them.

530-16. Portable Lamps. Portable lamps and work lights shall be equipped with approved portable cords, approved composition or metal-sheathed porcelain sockets and substantial guards.

Exception. The requirements of this Section shall not apply to portable lamps used as properties in a motion picture set or television stage set, on a studio stage or lot, or on location.

530-17. Portable Arc Lamps. Portable arc lamps shall be substantially constructed. The arc shall be provided with an enclosure designed to retain sparks and carbons and to prevent persons or materials from coming into contact with the arc or bare live parts. The enclosures shall be ventilated. All switches shall be of the externally operable type.

530-18. Overcurrent Protection — Short Time Rating.*

(a) General. Automatic overcurrent protective devices (circuit breakers or fuses) for feeders, and subfeeders for moving-picture studio stage set lighting and the stage cables for such stage set lighting, shall be rated or set to operate at not more than 400 per cent of the values given in Table 310-12 and Table 400-9.

*Special consideration is given to motion-picture studios because filming periods are of only a few minutes duration and are rarely longer than 10 minutes.

(b) Feeders. The feeders from the substations to the stages shall be protected by means of overcurrent devices having suitable ampacity (generally located in the substation). The overcurrent devices may be double-pole, or two single-pole devices may be used. There need be no pole or overcurrent coil in the neutral conductor. The overcurrent device setting for each feeder shall not exceed 400 per cent of the ampacity of the feeder, as given in Table 310-12 for the kind of insulation used.

(c) "Location Boards." Overcurrent protection (fuses or circuit breakers) shall be provided at the "location boards." The fuses in the "location boards" shall be not larger in rating than 400 per cent of the ampacity of the cables between the "location boards" and the plugging boxes.

(d) Plugging Boxes. Where plugging boxes are not provided with overcurrent protective devices, each cable or cord smaller than No. 8 supplied through a plugging box shall be attached to the plugging box by means of a plug containing two cartridge fuses or a circuit breaker. The rating of the fuses or the setting of the circuit breaker shall be not more than 400 per cent of the safe ampacity of the cables or cords as given in Tables 310-12, 310-13 and 400-8 for the kind of insulation used.

(e) Lighting. Work-lights, stand-lamps, and fixtures shall be connected to plugging boxes by means of plugs containing two cartridge fuses not larger than 20 amperes, or they may be connected to special outlets on circuits protected by fuses or circuit-breaker settings of not more than 20 amperes. Plug fuses shall not be used unless they are on the load side of the fuse or circuit breakers on the "location boards."

530-19. Grounding. Conduit, armored cable or metal raceways, and all noncurrent-carrying metal parts of appliances, devices and equipment shall be grounded as prescribed in Article 250. This shall not apply to pendant and portable lamps, nor to stage lighting and stage sound equipment, nor to other portable or semiportable special stage equipment, operating at not more than 150 volts to ground.

C. Dressing Rooms

530-31. Dressing Rooms. Fixed wiring in dressing rooms shall be installed in accordance with wiring methods covered in Chapter 3. Wiring for portable dressing rooms shall be of an approved type.

D. Viewing, Cutting and Patching Tables

530-41. Lamps at Tables. Only approved composition or metal-sheathed porcelain keyless lampholders, equipped with suitable means to guard lamps from physical damage and from film and film scrap, shall be used at patching, viewing and cutting tables.

E. Film Storage Vaults

530-51. Lamps in Cellulose Nitrate Film Storage Vaults. Lamps in cellulose nitrate film storage vaults shall be rigid fixtures of the glass enclosed and gasketed type. Lamps shall be controlled by a switch having a pole in each ungrounded conductor. This switch shall be located outside of the vault and provided with a pilot light to indicate whether the switch is on or off. This switch shall disconnect from all sources of supply all ungrounded conductors terminating in any outlet in the vault.

530-52. Motors and Other Electrical Equipment in Film Storage Vaults. No electric motors, heaters, portable lights, or other portable electric equipment shall be located in the film storage vaults.

F. Substations

530-61. Substations. Wiring and equipment above 600 volts shall conform to Article 710.

530-62. Low-Voltage Switchboards. On 600 volts or less switchboards shall conform to Article 384.

530-63. Overcurrent Protection of DC Generators. Three-wire DC generators shall have protection consisting of overcurrent devices having current ratings or settings in accordance with the generator rating. The overcurrent protective devices may be single-pole or two-pole and need not have a pole or over-current coil in the neutral lead (whether it is grounded or ungrounded).

530-64. Working Space and Guarding. Working space and guarding in permanent fixed substations shall conform to Sections 110-16 and 110-17. For guarding of live parts on motors and generators, see Section 430-11 and 430-14. Switchboards for voltage of not more than 250 volts DC between conductors when located in substations or switchboard rooms accessible to qualified persons only need not be dead-front.

530-65. Portable Substations. Wiring and equipment in portable substations shall conform to the sections applying to installations in permanent fixed substations, but, due to the limited space available, the working spaces may be reduced, provided that the equipment shall be so arranged that the operator may do his work safely, and so that other persons in the vicinity cannot accidentally come into contact with current-carrying parts or bring conducting objects into contact with them while they are energized.

530-66. Grounding at Substations. Noncurrent-carrying metal parts shall be grounded except the frames of DC circuit breakers installed on switchboards.

ARTICLE 540 — MOTION-PICTURE PROJECTORS

A. General

540-1. Scope. This Article applies to motion-picture projectors and associated equipment of the Professional and Nonprofessional Types.

B. Equipment and Projectors of the Professional Type

540-10. Professional Projector — Definition. The professional projector employs a 35-millimeter film which is 1⅜ inch wide and has on each edge 5.4 perforations per inch.

540-11. Enclosure. The professional type of projector, such as is commonly used in theaters and motion-picture houses, shall be located in an approved enclosure. Such enclosure shall not be considered as a hazardous location as defined in Article 500.

540-12. Motor-Driven Projectors. Motor-driven projectors shall be approved for the purpose as an assembly or shall comply with all of the following conditions:

(a) An approved projector shall be used.

(b) An approved projector lamp shall be used.

(c) Motors shall be so designed or guarded as to prevent ignition of film by sparks or arcs.

(d) Projectors shall be in charge of a qualified operator.

540-13. Conductor Size. Conductors supplying outlets for arc projectors of the professional type shall not be smaller than No. 8 and shall be of sufficient size for the projector employed. Conductors for incandescent type projectors shall conform to normal wiring standards as provided in Section 210-25.

540-14. Conductors on Lamps and Hot Equipment. Asbestos covered conductors type AA or other types of insulated conductors having a maximum operating temperature of 200°C (392°F) shall be used on all lamps or other equipment where the ambient temperature at the conductors as installed will exceed 50°C (122°F).

540-15. Flexible Cords. Cords approved for hard service in Table 400-11 shall be used on portable equipment.

540-16. Lamp Guards. Incandescent lamps in projection rooms or booths shall be provided with an approved lamp guard unless otherwise protected by noncombustible shades or other enclosures.

540-17. Location of Equipment. Motor-generator sets, transformers, rectifiers, rheostats, and similar equipment, for the supply or control of current to arc lamps on projectors shall, if practicable, be located in separate rooms. Where placed in the projector room, they shall be so located or guarded that arcs or sparks cannot come in contact with film, and motor-generator sets shall have the commutator end or ends protected as provided in Section 520-48.

540-18.

DELETED

540-19. Equipment Prohibited. Switches, overcurrent devices, or other equipment not normally required or used for projectors, sound reproduction, flood, or other special effect lamps or other equipment shall not be installed in such booths or rooms

Exception. Remote-control switches for the control of auditorium lights or a switch for the motor operating the curtain at the motion-picture screen.

540-20. Approval. Projectors and enclosures for arc or incandescent lamps, rectifiers, transformers, rheostats, and similar equipment, shall be of an approved type.

540-21. Marking. Projectors and other equipment as set forth in Section 540-20 shall be marked with the name or trademark of the maker and with the voltage and current for which they are designed.

540-22.

DELETED

C. Nonprofessional Type Projectors

540-30. Definition. The nonprofessional projector employs film other than that used on professional type projectors.

540-31. Booth Not Required. Projectors of the nonprofessional or miniature type, when employing only approved slow-burning (cellulose acetate or equivalent) film, may be operated without a booth.

540-32. Approval. Projectors, lamp enclosures, and current-controlling devices and similar devices shall be approved as component parts of the projector equipment.

540-33. Source of Illumination. The source of illumination shall be a lamp of a type approved for stereopticon use or for motion-picture projection.

540-34. Marking. Projectors shall be marked with name or trademark of the maker, with the current and voltage for which they are designed, and for projectors of this type using the standard 35-millimeter film, with the wording "For use with slow-burning films only."

540-35. Nonprofessional Film Marking. The slow-burning (cellulose acetate or equivalent) film shall have a permanent distinctive marker for its entire length identifying the manufacturer and the slow-burning character of the film stock.

D. Sound Recording and Reproduction

540-50. Sound Recording and Reproduction. Sound recording and reproduction equipment shall comply with Article 640.

ARTICLE 550 — MOBILE HOMES

550-1. Scope.

(a) The provisions of this Article cover the electric conductors and equipment installed within or on mobile homes and also the conductors that connect mobile homes to a supply of electricity.

Wherever the requirements of other Articles of the MASSACHUSETTS ELECTRICAL Code and Article 550 differ, the requirements of Article 550 shall apply.

(b) A mobile home not intended as a dwelling unit, as for example, equipped for sleeping purposes only, contractor's on-site offices, construction job dormitories, mobile studio dressing rooms, banks, clinics, mobile stores or intended for the display or demonstration of merchandise or machinery, shall not be required to meet the provisions of this Article pertaining to the number or capacity of circuits required. It shall, however, meet all other applicable requirements of this Article if provided with an electrical installation intended to be energized from a 115 volt or 115/230 volt AC power supply system.

(c) The provisions of this Article apply to mobile homes intended for connection to a wiring system nominally rated 115/230 volts, 3-wire AC, with grounded neutral.

550-2. Definition. Mobile Home: a vehicular, portable structure built on a chassis and designed to be used without a permanent foundation as a dwelling when connected to indicated utilities.

550-3. Power Supply. The mobile home service equipment shall be located adjacent to the mobile home and not mounted in or on the mobile home.

The power supply to the mobile home shall be feeder circuits consisting of not more than two mobile home supply cords each rated 50 amperes or permanently installed circuits.

Exception No. 1. A mobile home that is factory-equipped with gas or oil-fired central heating equipment and cooking appliances may be provided with a mobile home supply cord rated 40 amperes, minimum.

(a) Each such mobile home supply cord shall be approved for the purpose and have four conductors, one of which shall be identified by a continuous green color or a continuous green color with a yellow stripe. The attachment plug, connectors and mating receptacles shall be of a 3-pole, 4-wire grounding type covered by American Standard — C73 Attachment Plugs and Receptacles. The mobile home power-supply cord shall be permanently attached to the mobile home distribution panel. A suitable clamp or the equivalent shall be provided at the distribution panel to afford strain relief for the cord to prevent strain from being transmitted to the terminals.

The power supply cord shall be not less than 21 feet nor more than 26½ feet long.

(b) Second Supply Cord. Where the calculated load of the mobile home is in excess of 50 amperes, or where a separately metered appliance is installed in the mobile home, a second 50 ampere mobile home supply cord shall be installed. Where two cord supply systems are installed, they shall not be interconnected on either the line side or the load side except that the grounding circuits and grounding means shall be electrically interconnected.

(c) Permanent Wiring. Where the calculated load exceeds 100 amperes or where a permanent feeder is used the supply shall be by means of four permanently installed conductors in an approved wiring method, one conductor being identified by a continuous green color or a continuous green color with a yellow stripe.

550-4. Disconnecting Means and Branch Circuit Protective Equipment. The branch circuit equipment may be combined with the disconnecting means as a single assembly. Such a combination may be designated as a distribution panel.

Plug fuses and fuseholders shall be tamper-resistant, type "S," enclosed in dead-front fuse panels.

(a) Disconnecting Means. Disconnecting means shall be provided in each mobile home and shall be approved service entrance equipment consisting of circuit-breakers or a switch and fuses and their accessories installed in a readily accessible location near the point of entrance of the supply cord or conductors into the mobile home. This equipment shall contain a solderless type of grounding connector or bar for the purposes of grounding with sufficient terminals for all grounding conductors. The neutral bar termination of the grounded circuit conductors shall be insulated. The disconnecting equipment shall have a rating suitable for the connected load.

Where two power supply cords are installed disconnecting means shall be provided for each cord and may be combined in a single equipment but without electrical interconnections other than for grounding purposes.

A distribution panel main circuit-breaker shall be rated 50 amperes and employ a 2-pole circuit breaker rated 40 amperes for a 40-ampere supply cord, or 50 amperes for a 50-ampere supply cord. A distribution panel employing a disconnect switch and fuses shall be rated 60 amperes and shall employ a single 2-pole 60-ampere fuseholder with 40- or 50-ampere main fuses for 40- or 50-ampere supply cords, respectively. The outside of the distribution panel shall be plainly marked with the fuse size. The main circuit breakers or fuses shall be plainly marked "Main."

(b) Branch Circuit Protective Equipment. Branch circuit distribution equipment shall be installed in each mobile home and shall include overcurrent protection for each branch circuit consisting of either circuit breakers or fuses.

Where circuit breakers are provided for branch-circuit protection, 230-volt circuits shall be protected by 2-pole common or companion trip, or handle-tied paired circuit breakers.

The branch-circuit overcurrent devices shall be rated:

(1) not more than the circuit conductors; and

(2) not more than 150 per cent of the rating of a single appliance rated 10 amperes or more; but

(3) not more than the fuse size marked on the air conditioner or other motor-operated appliance.

(c) Electrical Nameplates. A metal nameplate on the outside adjacent to the supply cord entrance shall read, "This Mobile Home is Wired for 115/230 Volt, 3-wire, 60 Cycle Supply. Supply Cord 40 (or 50) amp." The voltage marking may read 120/240 Volts instead of 115/230 Volts.

550-5. Branch Circuits. The number of branch circuits required shall be determined in accordance with the following:

(a) Lighting. Based on 3 watts per square foot times outside dimensions of the mobile home (hitch excluded) divided by 115 volts to determine number of 15 or 20 ampere lighting area circuits, e.g.,

$$\frac{3 \times \text{Length} \times \text{Width}}{115 \times 15 \text{ (or 20)}} = \text{No. of 15 (or 20) ampere circuits.}$$

(b) Portable Appliances. There shall be a minimum of two 20 ampere branch circuits for receptacle outlets in the kitchen area, which may supply other receptacle outlets in the dining, laundry, and patio areas. These circuits shall supply only portable appliances.

(c) General Appliances. (Including Furnace, Water Heater, Range, and Central or Room Air Conditioner, Etc.) There shall be one or more circuits of adequate rating in accordance with the following:

(1) Ampere rating of fixed appliances not over 50 per cent of circuit rating if lighting outlets (receptacles, other than kitchen, dining area, and laundry, considered as lighting outlets) are on same circuit;

(2) For fixed appliances on a circuit without lighting outlets, the sum of rated amperes shall not exceed the branch-circuit rating for other than motor loads or 80 per cent of the branch-circuit rating for air conditioning or other motor loads;

(3) The rating of a single portable appliance on a circuit having no other outlets shall not exceed 80 per cent of the circuit rating;

(4) The rating of range branch circuit shall be based on the range demand as specified for ranges in Section 550-11 (b) (5).

550-6. Receptacle Outlets.

(a) All receptacle outlets:

(1) shall be of grounding type;

(2) shall be installed according to Section 210-7; and

(3) except when supplying specific appliances, receptacles shall be parallel blade, 15-ampere, 125-volt, either single or duplex.

(b) There shall be an individual outlet of the grounding type for each cord-connected fixed appliance installed.

(c) Except in the bath and hall areas, receptacle outlets shall be installed at all wall spaces 2 feet wide or more, so that no point along the floor line is more than 6 feet, measured horizontally, from an outlet in that space. Except as explained in the following, receptacle outlets are not required for wall spaces occupied by kitchen or wardrobe cabinets.

In addition, a receptacle outlet shall be installed:

(1) Over counter tops in the kitchen (at least one on each side of the sink if counter tops are on each side);

(2) Adjacent to the refrigerator and free-standing gas-range space;

(3) At counter top spaces for built-in vanities;

(4) At counter top spaces under wall-mounted cabinets.

(d) Receptacle outlets shall not be installed within or adjacent to a shower or bathtub space.

550-7. Fixtures and Appliances.

(a) Water heaters, refrigerators, air conditioning equipment, ranges, electric heaters, washers, dryers and other like appliances shall be of an approved type and shall be connected in an approved manner and securely fastened in position. (See Section 550-9 for provisions on grounding.)

(b) (1) Specifically approved pendant-type fixtures or pendant cords may be installed in mobile homes.

(2) If a lighting fixture is provided over a bathtub or in a shower stall, it shall be of the approved enclosed and gasketed type.

(3) Switches shall not be located inside the tub or shower space.

550-8. Wiring Methods and Materials. Except as specifically limited in this Section the wiring methods and materials included in the National Electrical Code shall be used in mobile homes.

(a) Nonmetallic outlet boxes are acceptable only with nonmetallic sheathed cable.

(b) Nonmetallic cable located 15 inches or less above the floor, if exposed, shall be protected from physical damage by covering boards, guard strips, or conduit. Cable likely to be damaged by stowage shall be so protected in all cases.

(c) Metal-clad and nonmetallic cables may be passed through the centers of the wide side of 2 by 4 studs. However, they shall be protected where they pass through 2 by 2 studs or at other studs or frames where the cable or armor would be less than 1½ inches from the inside or outside surface. Steel plates on each side of the cable, or a tube, with not less than No. 16 manufacturer's standard gage wall thickness, are required to protect the cable. These plates or tubes shall be securely held in place.

(d) Where metallic faceplates are used they shall be effectively grounded.

(e) If the range, clothes dryer, or similar appliance is connected by metal-clad cable or flexible conduit, a length of free cable or conduit should be provided to permit moving the appliance. The cable or flexible conduit should be adequately secured to the wall. Clearance space behind a range may provide the required protection when a range is connected by Type SE cable. When used, Type SE cable shall have an identified and insulated neutral plus an equipment grounding conductor. Nonmetallic cable (Type NM) shall not be used to connect a range.

(f) Rigid metal conduit shall be provided with a locknut inside and outside the box, and a conduit bushing shall be used on the inside. Inside ends of the conduit shall be reamed.

(g) Switches shall be rated as follows:

(1) For lighting circuits, switches shall have a 10-ampere 125 volt rating; or higher, if needed for the connected load.

(2) For motors or other loads, switches shall have ampere or horsepower ratings or both adequate for loads controlled. (An "AC general use" snap switch may control a motor 2 horsepower or less with full-load current not over 80 per cent of the switch ampere rating.)

(h) At least 4 inches of free conductor shall be left at each outlet box except where conductors are intended to loop without joints.

(i) Under Chassis Wiring (Exposed to Weather).

(1) When outdoor or under chassis wiring is exposed to moisture and physical damage it shall be protected by rigid metal conduit or liquid-tight flexible metal conduit, except electrical metallic tubing may be used when closely routed against frames and equipment enclosures.

(2) The conductors shall be Type NMC, RW, TW, or equivalent.

550-9. Grounding.

Grounding of both electrical and non-electrical metal parts in a mobile home is through connection to a grounding bus in the mobile home distribution panel. The grounding bus is grounded through the green-colored conductor in the supply cord or the feeder wiring to the service ground in the service entrance equipment located adjacent to the mobile home location. Neither the frame of the mobile home nor the frame of any appliance may be connected to the neutral conductor in the mobile home.

(a) Insulated Neutral.

(1) The grounded circuit conductor (neutral) shall be insulated from the grounding conductors and from equipment enclosures and other grounded parts. The grounded (neutral) circuit terminals in the distribution panel and in ranges, clothes dryers, counter-mounted cooking units, and wall-mounted ovens are to be insulated from the equipment enclosure. Bonding screws, straps, or buses in the distribution panel or in appliances are to be removed and discarded.

(2) Connection of ranges and clothes dryers shall be made with 4 conductor cord and 3-pole, 4-wire grounding type plugs, or by armored cable or conductors enclosed in flexible steel conduit.

(b) Equipment Grounding Means.

(1) The green-colored grounding wire in the supply cord or permanent feeder wiring shall be connected to the grounding bus in the distribution panel or disconnecting means.

(2) The chassis shall be grounded. The grounding conductor may be solid or stranded, insulated or bare, and shall be an armored grounding conductor or routed in conduit if No. 8 AWG. The conductor, if No. 6 AWG or larger, may be run without metal covering. The grounding conductor shall be connected between distribution panel grounding terminal and a terminal on the chassis. Grounding terminals shall be of the solderless type and approved as pressure terminal connectors recognized for the wire size employed.

(3) In the electrical system, all exposed metal parts, enclosures, frames, lamp fixture canopies, etc. shall be effectively bonded to the grounding terminal or enclosure of the distribution panel.

(4) Cord-connected appliances, such as washing machines, clothes dryers, refrigerators, and the electrical system of gas ranges, etc. shall be grounded by means of an approved cord with grounding conductor and grounding type plug.

(c) Grounding of Non-current-carrying Metal Parts. All major exposed metal parts that may become energized, including the water, gas and waste plumbing, the roof and outer metallic covering, the chassis and metallic circulating air ducts, shall be effectively bonded to the grounding terminal or enclosure of the distribution panel or to the metal chassis. See Section 550-9 (b) (2) for bonding of the chassis to the distribution panel grounding terminal.

550-10. Testing. Dielectric Strength Test. The wiring of each mobile home shall be subjected to a 1-minute, 900-volt, dielectric strength test (with all switches closed) between live parts (including neutral) and the mobile home ground. Alternatively, the test may be performed at 1,088 volts for 1 second. This test shall be performed after branch circuits are complete and after fixtures or appliances are installed.

Exception: Fixtures or appliances which are approved shall not be required to withstand the dielectric strength test.

550-11. Calculations. The following method is to be employed in computing the supply cord and distribution panel load for each power supply assembly for each mobile home in lieu of the procedure shown in Article 220 and is based on 3 wire, 115/230 volt supply with 115 volt loads balanced between the two legs of the 3 wire system.

(a) Lighting and Small Appliance Load:

Lighting Watts: Length times width of mobile home (outside dimensions, exclusive of hitch) times 3 watts per square foot; e.g.,

Length × width × 3 = ...lighting watts.

Small appliance Watts: Number of circuits times 1,500 watts for each 20-ampere appliance receptacle circuit (see definition of Appliance, Portable with note); e.g.,

Number of circuits × 1,500 = ... small appliance watts.

Total: Lighting watts plus small appliance = ... total watts.

First 3,000 total watts at 100 per cent plus remainder at 35 per cent = ... watts to be divided by 230 volts to obtain current (amperes) per leg.

(b) Total load for determining power supply is the summation of:

(1) Lighting and small appliance load as calculated in Section 550-11(a).

(2) Name plate amperes for motors and heater loads (exhaust fans, air conditioners,* electric, gas, or oil heating).**

* Omit smaller of these two, except include blower motor if used as air conditioner evaporator motor.

** When an air conditioner is not installed and a 40-ampere power supply cord is provided, allow 15 amperes per leg for air conditioning.

(3) 25% of current of largest motor in (2).

(4) Total of nameplate amperes for: Disposal, Dishwasher, Water heater, Clothes dryer, Wall-mounted oven, Cooking units.

Where number of these appliances exceeds three use 75% of total.

(5) Derive amperes for free standing range (as distinguished from separate ovens and cooking units) by dividing values below by 230 volts.

Name Plate Rating	Use
10,000 w × or less	80 per cent of rating
10,001-12,500 w	8,000 w
12,501-13,500 w	8,400 w
13,501-14,500 w	8,800 w
14,501-15,500 w	9,200 w
15,501-16,500 w	9,600 w
16,501-17,500 w	10,000 w

(6) If outlets or circuits are provided for other than factory installed appliances include the anticipated load.

See following Example for illustration of application of this calculation.

Example

A mobile home is 70 × 10 feet and has two portable appliance circuits, a 1000 watt 230 volt heater, a 200 watt 115 volt exhaust fan, a 400 watt 115 volt dishwasher and a 7000 watt electric range.

Lighting and small appliance load

Lighting 70 × 10 × 3 = 2100 watts
Small appliance 1500 × 2 = 3000 watts
5100 watts

1st 3000 watts at 100% 3000
Remainder (5,100 — 3,000 = 2,100) at 35% 735
3735

$\frac{3735}{230}$ = 16 amperes per leg

1000 watt (heater) ÷ 230 = 4.4 amp
200 watt (fan) ÷ 115 = 1.7 amp
400 watt (dishwasher) ÷ 115 = 3.5 amp
7000 watt (range) × .8 ÷ 230 = 24. amp

	Amperes per leg	
	A	*B*
Lighting and appliances	16	16
Heater (230 volt)	4	4
Fan (115 volt)	2	—
Dishwasher (115 volt)	—	4
Range	24	24
Totals	46	48

Based on the higher current calculated for either leg, use one 50 ampere supply cord.

ARTICLE 551 — TRAVEL TRAILERS

551-1. Scope.

(a) The provisions of this Article cover the electric conductors and equipment installed within or on Travel Trailers and also on conductors that connect them to a supply of electricity.

> Wherever the requirements of other Articles of the MASSACHUSETTS ELECTRICAL CODE and Article 551 differ, the requirements of Article 551 shall apply.

(b) A Travel Trailer not intended as a dwelling unit, as for example, for use as a mobile store, an office, a schoolroom or designed for the display or demonstration of merchandise or machinery shall not be required to meet the provisions of this Article pertaining to the number or capacity of circuits required. It shall, however, meet all other applicable requirements of this Article if provided with an electrical installation intended to be energized from a 115 volt, AC power supply system.

(c) The provisions of this Article apply to the electrical equipment and materials of Travel Trailers intended for connection to a wiring system nominally rated 115 volts, 2 wire, AC, with a grounded neutral.

551-2. Definition. Travel Trailer: A vehicular portable structure built on a chassis, designed to be used as a temporary dwelling for travel, recreational, and vacation use, permanently identified "Travel Trailer" by the manufacturer on the trailer, and when factory equipped for the road, being of body width not exceeding 8 feet and being of any length provided its gross weight does not exceed 4,500 pounds, or being of any weight provided its body length does not exceed 29 feet.

551-3. Power Supply. The Travel Trailer service equipment shall be located adjacent to the Travel Trailer parking location and not mounted in or on the Travel Trailer.

(a) The power supply to the Travel Trailer shall be a feeder circuit supply cord approved for the purpose rated 15, 20 or 30 amperes, 115 volts, and shall have three conductors, one of which shall be identified by a continuous green color or a continuous green color with a yellow stripe. The attachment plug, connectors and mating receptacles shall be of a 2-pole, 3-wire grounding type covered by American Standard C73 Attachment Plugs and Receptacles.

(b) The supply cord shall be not less than 20 feet nor more than 26½ feet long and shall be either separable or permanently attached.

(1) Separable Cord Set. When a separable cord set, consisting of a cord, male and female fittings, is provided by the travel trailer manufacturer, the travel trailer shall be equipped with a permanently-mounted, approved, male recessed-type attachment plug (motor base receptacle) wired directly to the distribution panel in an approved manner by means of approved service cable. The supply end of the cord set shall be equipped with an attachment plug of the type described in Section 551-3(a).

(2) Permanently Connected Power Cord. The cord shall be connected directly to the terminals of the distribution panel and provided with means to prevent strain from being transmitted to the terminals. The supply end of the cord shall be equipped with an attachment plug of the type described in Section 551-3(a).

(d) Supply Cords shall be as follows:

(1) 15 ampere No. 14/3 AWG for travel trailers which have a single 15 ampere general purpose branch circuit and gas or oil-fired heating and cooking appliance.

(2) 20 ampere No. 12/3 AWG for travel trailers which have a single 20 ampere general purpose branch circuit and gas or oil-fired heating and cooking appliance.

(3) 30 ampere No. 10/3 AWG for travel trailers with branch circuits in accordance with Section 551-5 (b).

551-4. Disconnecting Means and Branch Circuit Protective Equipment. The branch circuit equipment may be combined with the disconnecting means as a single assembly. Such a combination may be designated as a distribution panel.

Plug fuses and fuseholders shall be tamper-resistant, type "S" enclosed in dead-front fuse panels.

(a) Disconnecting Means. Disconnecting means shall be provided in each travel trailer and shall be approved service entrance equipment consisting of circuit-breakers or a switch and fuses and their accessories installed in a readily accessible location near the point of entrance of the supply cord or conductors into the travel trailer. This equipment shall contain a solderless type of grounding connector or bar for the purposes of grounding with sufficient terminals for all grounding conductors. The neutral bar termination of the grounded circuit conductors shall be insulated.

The disconnecting equipment shall have a rating suitable for the connected load. Travel trailers in which only a single branch circuit is installed may use a branch-circuit breaker or pull-out type of fuseholder as disconnecting means if approved for use as service equipment.

(b) Branch Circuit Protective Equipment. Branch circuit distribution equipment shall be installed in each travel trailer and shall include overcurrent protection for each branch circuit consisting of either circuit breakers or fuses.

The branch-circuit overcurrent devices shall be rated:

(1) not more than the circuit conductors; and

(2) not more than 150 per cent of the rating of a single appliance rated 10 amperes or more.

(c) Labeling at Electrical Entrance. Each travel trailer shall have permanently affixed to the exterior skin, at or near the point of entrance of the power supply cord, a metal tag reading: "This travel trailer is wired for 110/125 volt AC service. Do not connect to higher voltage."

551-5. Branch Circuits.

(a) Travel trailers with not more than six general appliance and receptacle outlets combined shall have not less than either:

(1) One general purpose (lighting) branch circuit, 15 amperes, No. 14 AWG circuit, to supply these outlets, or

(2) One general purpose (lighting and appliance) branch circuit, 20 amperes, No. 12 AWG circuit, to supply these outlets, provided that the total rating of fixed appliances connected to this circuit shall not exceed 5 amperes or 600 watts.

Note: Travel trailers, wired in accordance with (1) and (2) shall be equipped with gas or oil-fired heating and cooking appliances.

(b) Travel trailers with more than six general appliance and receptacle outlets combined shall have not less than:

(1) One general purpose (lighting and appliance) branch circuit, 20 amperes or No. 12 gage conductors, minimum, which shall supply current to lighting outlets and receptacles only (shall not supply receptacles in cooking and dining areas) and may supply fixed or portable appliances such as electric water heaters. The total rating of such fixed or factory installed appliances shall not exceed 9 amperes or 1,000 watts, and

(2) One appliance branch circuit, as follows: 20 amperes, No. 12 gage conductors, minimum, which shall supply current to receptacle outlets only in cooking and dining areas.

551-6. Receptacle Outlets.

(a) All receptacle outlets; (1) shall be of the grounding type; (2) shall be installed according to Section 210-7; and (3) shall be of the parallel blade, 15 ampere, 125 volt type either single or duplex.

(b) There shall be an individual outlet of the grounding type for each cord-connected fixed appliance installed.

(c) Except in the bath area, receptacle outlets shall be installed at all wall spaces 2 feet wide or more, so that no point along the floor line is more than 6 feet, measured horizontally, from an outlet in that space. Except as explained in the following, receptacle outlets are not required for wall spaces that are partially or fully occupied by kitchen cabinets, wardrobes, built-in furniture, or similar facilities.

In addition, a receptacle outlet shall be installed:

(1) Over counter tops in the kitchen and dining area.

(2) Adjacent to the refrigerator space, except when a gas-operated refrigerator containing no electrical circuit is factory installed.

(3) Adjacent to a gas range space, except when a gas cooking appliance containing no electrical circuit is factory installed.

(4) At counter top spaces for built-in vanities.

(d) No receptacle outlet shall be provided adjacent to a shower or bathtub.

551-7. Fixtures and Appliances.

(a) Fixed Appliances:

(1) All fixed appliances shall be of an approved type and shall be connected in an approved manner and securely fastened in position. (See Section 551-9 for provisions on grounding.)

(b) Lighting Fixtures:

(1) Pendant-type fixtures or pendant cords shall not be installed.

(2) If a lighting fixture is provided over a bathtub or in a shower stall, it shall be of the approved enclosed and gasketed type.

(3) Switches shall not be located inside the tub or shower space.

551-8. Wiring Methods and Materials. Except as specifically limited in this section, the wiring methods and materials included in the National Electrical Code shall be used in Travel Trailers.

(a) Nonmetallic outlet boxes are acceptable only with nonmetallic sheathed cable.

(b) Nonmetallic cable located 15 inches or less above the floor, if exposed, shall be protected from physical damage by covering boards, guard strips, or conduit. Cable likely to be damaged by stowage shall be so protected in all cases.

(c) Metal-clad and nonmetallic cables may be passed through the centers of the wide side of 2 by 4 studs. However, they shall be protected where they pass through 2 by 2 studs or at other studs or frames where the cable or armor would be less than 1½ inches from the inside or outside surface. Steel plates on each side of the cable, or a tube, with not less than No. 16 manufacturer's standard gage wall thickness, are required to protect the cable. These plates or tubes shall be securely held in place. When the thickness of studs or frames make it impractical or impossible to use metal plates or tubes, particular care shall be exercised in the design and production of the travel trailer so as to avoid contacting the cables with nails, screws, or other fasteners, such care in design shall include appropriate routing of the cables through studs or frames at locations where the likelihood of their being contacted by nails, screws, or other fasteners subsequent to production is remote.

(d) Where metallic faceplates are used they shall be effectively grounded.

(e) Switches shall be rated as follows:

(1) For lighting circuits, switches shall have a 10-ampere, 125 volt rating; or higher, if needed for the connected load.

(2) For motors or other loads, switches shall have ampere or horsepower ratings or both adequate for loads controlled. (An "AC general use" snap switch may control a motor 2 horsepower or less with full-load current not over 80 per cent of the switch ampere rating.)

(f) At least 4 inches of free conductor shall be left at each outlet box except where conductors are intended to loop without joints.

(g) Under Chassis Wiring (Exposed to Weather).

(1) When outdoor or under chassis wiring is exposed to moisture and physical damage it shall be protected by rigid metal conduit or liquid-tight flexible metal conduit, except electrical metallic tubing may be used when closely routed against frames and equipment enclosures.

(2) The conductors shall be type NMC, RW, TW, or equivalent.

551-9. Grounding.

Grounding of both electrical and non-electrical metal parts in a Travel Trailer is through connection to a grounding bus in the Travel Trailer distribution panel. The grounding bus is grounded through the green-colored conductor in the supply cord or the feeder wiring to the service ground in the service entrance equipment located adjacent to the Travel Trailer location. Neither the frame of the Travel Trailer nor the frame of any appliance may be connected to the neutral conductor in the Travel Trailer.

(a) Insulated Neutral. The ground circuit conductor (neutral) shall be insulated from the grounding conductors and from equipment enclosures and other grounded parts. The grounded (neutral) circuit terminals in the distribution panel and in countermounted cooking units are to be insulated from the equipment enclosure. Bonding screws, straps or buses in the distribution panel or in appliances are to be removed and discarded.

(b) Equipment Grounding Means.

(1) The green-colored grounding wire in the supply cord or permanent feeder wiring shall be connected to the grounding bus in the distribution panel or disconnecting means.

(2) The chassis shall be grounded. The grounding conductor may be solid or stranded, insulated or bare, and shall be an armored grounding conductor or routed in conduit if No. 10 AWG. The conductor, if No. 8 AWG stranded or larger, may be run without metal covering. The grounding conductor shall be connected between distribution panel grounding terminal and a terminal on the chassis. Grounding terminals shall be of the solderless type and approved as pressure terminal conductors recognized for the wire size employed. The grounding conductors shall be routed so as not to be exposed to physical damage; protection can be afforded by following the configuration of the chassis.

(3) In the electrical system, all exposed metal parts, enclosures, frames, lamp fixture canopies, etc. shall be effectively bonded to the grounding terminal or enclosure of the distribution panel.

(4) Cord-connected appliances, such as refrigerators, and the electrical system of gas ranges, shall be grounded by means of an approved cord with grounding conductor and grounding type plug.

(c) Grounding of Noncurrent-Carrying Metal Parts. All major exposed metal parts that may become energized, including the water, gas, and waste plumbing, the roof and outer metallic covering, the chassis and metallic circulating air ducts, shall be effectively bonded to the grounding terminal or enclosure of the distribution panel or to the metal chassis. See Section 551-9 (b) (2).

551-10. Testing. Dielectric Strength: The wiring of each Travel Trailer shall be capable of withstanding, without breakdown, for a period of 1 minute, the application of an alternating potential of 900 volts between live parts and noncurrent-carrying metal parts.

Fixtures or permanently installed appliances shall not be required to withstand the dielectric test if they have been approved.

Chapter 6. Special Equipment

ARTICLE 600 — ELECTRIC SIGNS AND OUTLINE LIGHTING

A. General

600-1. Scope. The provisions of this Article shall apply to the installation of conductors and equipment for electric signs and outline lighting as defined in Article 100.

600-2. Disconnect Required. Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally operable switch or breaker which will open all ungrounded conductors and shall be suitable for conditions of installation, such as exposure to the weather.

(a) In Sight of Sign. The switch or breaker required by Section 600-2 shall be within sight of the sign or outline lighting which it controls or may be located elsewhere when capable of being locked in the open position.

(b) Control Switch Rating. Switches, flashers, and similar devices controlling transformers shall be either of a type approved for the purpose, or have a current rating not less than twice the current rating of the transformers. On alternating-current circuits, general use alternating-current snap switches may be used to control inductive loads other than motors, not exceeding the ampere rating of switch. See Section 380-14.

600-5. Grounding.

(a) Signs, troughs, tube terminal boxes and other metal frames shall be grounded in the manner specified in Article 250 of this Code, unless they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons.

(b) Isolated noncurrent-carrying metal parts of outline lighting may be bonded by No. 14 conductors and grounded in accordance with Article 250.

(c) Signs of the portable incandescent or fluorescent-lamp type in which the open circuit voltage does not exceed 150 volts to ground are not required to be grounded.

600-6. Load of Branch Circuit. Circuits shall be so arranged that the load imposed by outlets, lamps, and transformers connected to them, shall in no case exceed the rating of the branch circuit.

Circuits which supply lamps, ballasts, and transformers or combinations thereof may be rated not to exceed 20 amperes.

Circuits containing electric discharge lighting transformers exclusively shall not be rated in excess of 30 amperes.

600-7. Marking.

(a) Signs shall be marked with the maker's name, and for incandescent-lamp signs with the number of lampholders, and for electric discharge signs with input amperes at full load and input voltage. The marking of the sign shall be visible for inspection after installation.

(b) Transformers shall be marked with the maker's name, and transformers for electric discharge signs shall be marked with the input rating in amperes or volt-amperes, the input voltage and the open-circuit high-tension voltage.

600-8. Enclosures. Enclosures for signs and outline lighting shall conform to the following:

(a) Conductors and Terminals. Conductors and terminals in sign boxes, cabinets, and outline troughs shall be enclosed, except the supply leads.

(b) Cutouts, Flashers, Etc. Cutouts, flashers, and similar devices shall be enclosed in metal boxes the doors of which shall be arranged so that they can be opened without removing obstructions or finished parts of the enclosure.

(c) Strength. Enclosures shall have ample strength and rigidity.

(d) Material. Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other noncombustible material. Wood may be used for external decoration if placed not less than 2 inches from the nearest lampholder or current-carrying part.

(e) Minimum Thickness — Enclosure Metal. Sheet copper shall be at least 20 ounce (0.028 inch). Sheet steel may be of No. 28 USS gage (.0149 inch) except that for outline lighting and for electric discharge signs sheet steel shall be of No. 24 USS gage (.0239 inch), unless ribbed, corrugated or embossed over its entire surface, when it may be of No. 26 USS gage (.0179 inch).

(f) Protection of Metal. All steel parts of enclosures shall be galvanized or otherwise protected from corrosion.

(g) Enclosures Exposed to the Weather. Enclosures for outside use shall be weatherproof and shall have an ample number of drain holes, each not larger than ½ inch or smaller than ¼ inch. Wiring connections shall not be made through the bottoms of enclosures exposed to the weather unless the enclosures are of the raintight type.

B. Signs and Outline Lighting — 600 Volts or Less

600-21. Installation of Conductors. Conductors shall be installed as follows:

(a) Wiring Method. Conductors shall be installed as open conductors on insulators, in rigid metal conduit, flexible metal conduit, electrical metallic tubing, metal-clad cable, metal troughing, Type ALS cable or Type MI cable.

(b) Insulation and Size. Conductors shall be of a type approved for general use and shall be no smaller than No. 14.

Exception No. 1. Conductors in portable signs, short leads permanently attached to lampholders or ballasts, and leads in wiring channels which are permanently attached to electric discharge lampholders or electric discharge ballasts and which are not longer than 8 feet may be smaller than No. 14 but shall not be smaller than No. 18 and shall be of a type approved for the purpose.

Exception No. 2. Conductors, for signs with multiple incandescent lamps requiring one conductor from a control to one or more lamps whose total load does not exceed 250 watts, may be smaller than No. 14 but shall not be smaller than No. 18 if in an approved cable assembly of two or more conductors.

(c) Exposed to the Weather. Conductors in raceways, armored cable or enclosures exposed to the weather, shall be of the lead-covered type or other type specially approved for the conditions, except where rigid conduit, electrical metallic tubing or enclosures are made raintight and arranged to drain.

(d) Number of Conductors in Raceway. Number of conductors in raceway for sign flashers may be in accordance with Table 1 of Chapter 9.

(e) Open Conductors. Open conductors on insulators shall comply with the provisions of Sections 300-2 to 300-22 inclusive, and, if outdoors, Article 730, except that the separation between conductors need be only 2 inches.

Exception: Open conductors may be supported by lampholders located not more than 1 foot apart.

(f) Conductors Soldered to Terminals. Where the conductors are fastened to lampholders other than of the pin type, they shall be soldered to the terminals and the exposed parts of conductors and terminals shall be treated to prevent corrosion. Where the conductors are fastened to pin-type lampholders which protect the terminals from the entrance of water, and which have been found acceptable for sign use, the conductors shall be of the stranded type but need not be soldered to the terminals.

600-22. Lampholders. Lampholders shall be of the unswitched type having bodies of suitable insulating material and shall be so constructed and installed as to prevent turning. Miniature lampholders shall not be employed for outdoor signs and outline lighting.

C. Signs and Outline Lighting — Exceeding 600 Volts

600-31. Installation of Conductors. Conductors shall be installed as follows:

(a) Wiring Method. Conductors shall be installed as open work, as concealed conductors on insulators, in rigid or flexible metal conduit, or in electrical metallic tubing.

(b) Insulation and Size. Conductors shall be of a type approved for the purpose and for the voltage of the circuit and shall be not smaller than No. 14.

Exception No. 1. Leads in wiring channels which are permanently attached to electric discharge lampholders or electric discharge ballasts and which are not longer than 8 feet may be smaller than No. 14 but shall not be smaller than No. 18 and shall be of a type approved for the purpose.

Exception No. 2. Leads in show-window displays or small portable signs that run from the line ends of the tubing to the secondary windings of the transformer where they are permanently attached within the transformer enclosure and which are not longer than eight (8) feet may be smaller than No. 14, but shall not be smaller than No. 18 and shall be of a type approved for the purpose.

(c) Bends in Conductors. Sharp bends in the conductors shall be avoided.

(d) Open Conductors — Indoors. Open conductors indoors shall be mounted on noncombustible, nonabsorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least 1½ inches shall be maintained between conductors and between conductors and other objects. Conductors shall not be located where subject to physical damage.

(e) Concealed Conductors on Insulators — Indoors. Concealed conductors on insulators shall be separated from each other and from all objects other than the insulators on which they are mounted by a spacing of not less than 1½ inches for voltages above 10,000 volts, and not less than 1 inch for voltages of 10,000 or less. They shall be installed in channels lined with noncombustible material and used for no other purpose, except that the primary circuit conductors may be in the same channel. The insulators shall be of noncombustible, nonabsorptive material.

(f) Conductors in Raceways. Where the conductors are covered with lead or other metal sheathing, the covering shall extend beyond the end of the raceway, and the surface of the cable shall not be injured where the covering terminates.

(1) In damp or wet locations, the insulation on all conductors shall extend beyond the metal covering or raceway at least 4 inches for voltages over 10,000, 3 inches for voltages over 5,000 but not exceeding 10,000, and 2 inches for voltages of 5,000 or less.

(2) In dry locations the insulation shall extend beyond the end of the metal covering or raceways not less than 2½ inches for voltages over 10,000, 2 inches for voltages over 5,000 but not exceeding 10,000, and 1½ inches for voltages of 5,000 or less.

(3) For conductors at grounded midpoint terminals, no spacing is required.

(4) A metal raceway containing a single conductor from one secondary terminal of a transformer shall not exceed twenty feet in length.

(g) Open Conductors — Outdoors. Open conductors outdoors shall be mounted on noncombustible, nonabsorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least two inches shall be maintained between conductors, and between conductors and other objects.

Where subject to physical damage, or where within reach from ground, roof, or window, conductors shall be enclosed in raceways or suitably guarded. Where guarded, a spacing of not less than 1½ inches shall be maintained between conductors and the enclosure unless the enclosure is nonconducting and noncombustible.

(h) Show Windows and Similar Locations. Conductors that hang freely in the air, away from combustible material, and where not subject to physical damage, as in some show-window displays, need not be otherwise protected.

(i) Conductors may be run from the ends of tubing to the grounded midpoint of transformers specifically designed for the purpose and provided with terminals at the midpoint. Where such connections are made to the transformer grounded midpoint, the connections between the high-voltage terminals of the transformer and the line ends of the tubing shall be as short as possible.

600-32. Transformers. Transformers shall comply with the following:

(a) Voltage. The transformer secondary open-circuit voltage shall not exceed 15,000 volts with an allowance on test of 1000 volts additional. In end-grounded transformers the secondary, open-circuit voltage shall not exceed 7,500 volts with an allowance on test of 500 volts additional.

(b) Type. Transformers shall be of a type approved for the purpose and shall be limited in rating to a maximum of 4,500 volt-amperes.

Open core-and-coil type transformers shall be limited to 5,000 volts with an allowance on test of 500 volts, and to indoor applications in small portable signs.

Transformers for outline lighting installations shall have secondary current ratings not in excess of 30 milliamperes except where they and all wiring connected to them are installed in accordance with the provisions of Article 410 for electric discharge lighting of the same voltage.

(c) Exposed to Weather. Transformers used outdoors shall be of the weatherproof type or shall be protected from the weather by enclosure in the sign body or in a separate metal box.

(d) Transformer Secondary Connections. The high-voltage windings of transformers shall not be connected in parallel; and shall not be connected in series, except that two transformers each having one end of its high-voltage winding connected to the metal enclosure may have their high-voltage windings connected in series to form the equivalent of a midpoint grounded transformer. The grounded ends shall be connected by insulated conductors not smaller than No. 14.

Exception: Transformers for small portable signs, show windows, and similar locations that are equipped with leads permanently attached to the secondary winding of the transformer enclosure and that do not extend more than eight (8) feet beyond the enclosure for attaching to the line ends of the tubing may have leads smaller than No. 14, but shall not be smaller than No. 18 and shall be of a type approved for the purpose.

(e) Accessibility. Transformers shall be accessible.

600-33. Electric Discharge Tubing. Electric discharge tubing shall conform to the following:

(a) Design. The tubing shall be of such length and design as not to cause a continuous over-voltage on the transformer.

(b) Support. Tubing shall be adequately supported on noncombustible, nonabsorptive supports. Tubing supports should, where practicable, be adjustable.

(c) Contact with Flammable Material and Other Surfaces. The tubing shall be free from contact with flammable material and shall be located where not normally exposed to physical damage. Where operating in excess of 7,500 volts, the tubing shall be supported on noncombustible, nonabsorptive, insulating supports which maintain a spacing of not less than ¼ inch between the tubing and the nearest surface.

600-34. Terminals and Electrode Receptacles for Electric Discharge Tubing. Terminals and electrode receptacles for electric discharge tubing shall comply with the following:

(a) Terminals. Terminals of the tubing shall be inaccessible to unqualified persons and isolated from combustible material and grounded metal or shall be enclosed. Where enclosed they shall be separated from grounded metal and combustible material by noncombustible, nonabsorptive, insulating material approved for the purpose or by 1½ inches of air. Terminals shall be relieved from stress by the independent support of the tubing.

(b) Tube Connections Other Than With Receptacles. Where tubes do not terminate in receptacles designed for the purpose, all live parts of tube terminals and conductors shall be so supported as to maintain a separation of at least 1½ inches between conductors or between conductors and any grounded metal.

(c) Receptacles. Electrode receptacles for the tubing shall be of noncombustible, nonabsorptive insulating material approved for the purpose.

(d) Bushings. Where electrodes enter the enclosure of outdoor signs or of an indoor sign operating at a voltage in excess of 7,500 volts, bushings shall be used unless receptacles are provided or the sign is wired with bare wire mounted on approved supports which maintain the tubing in proper position. Bushings shall be of noncombustible, nonabsorptive material. Where bare wiring is used, the conductor shall be not less than No. 14 solid copper, shall be supported so as to prevent sagging and lessening of the spacing required elsewhere in this Article, and electrode terminal assemblies shall be of an approved type and supported not more than 6 inches from the electrode terminals.

(e) Show Windows. In the exposed type of show-window signs, terminals shall be (1) enclosed by receptacles approved for the purpose or (2) where hanging in air, free from grounded surfaces, enclosed in sleeves of vulcanized fiber, phenolic composition, or other suitable material which overlaps all live parts by at least ½ inch.

(f) Receptacles and Bushing Seals. A flexible, nonconducting seal may be used to close the opening between the tubing and the receptacle or bushing against the entrance of dust or moisture. This seal shall not be in contact with grounded conductive material and shall not be depended upon for the insulation of the tubing.

(g) Enclosures of Metal. Enclosures of metal for electrodes shall be of not less than No. 24 USS gage (.0239 inch) sheet metal.

(h) Enclosures of Insulating Material. Enclosures of insulating material shall be noncombustible, nonabsorptive and approved for the voltage of the circuit.

600-35. Switches on Doors. Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to the general public, shall either be provided with interlock switches which on the opening of the doors or covers disconnect the primary circuit, or shall be so fastened that the use of the other than ordinary tools will be necessary to open them.

ARTICLE 610 — CRANES AND HOISTS

A. Scope and Use

610-1. Scope. The provisions of this Article shall apply to the installation of cranes, crane runways, hoists, and monorails, and shall be additional to, or amendatory of, the requirements prescribed in Articles 100 to 480, inclusive, of this Code.

For definition of various kinds of cranes and hoists see American Standard Safety Code for Cranes, Derricks, and Hoists, ASA B30.2—1943.

610-2. Particular Locations.

(a) Ignitible Material Hazards. Installations in hazardous locations shall comply with the provisions of Section 503-13.

(b) Combustible Materials. Where a crane operates over readily combustible material, the resistors shall be placed in a well-ventilated cabinet composed of noncombustible material so constructed that it will not emit flames or molten metal.

Exception: Resistors may be located in a cage or cab constructed of noncombustible material which encloses the sides of the cage or cab from the floor to a point at least 6 inches above the top of the resistors.

B. Wiring

610-11. Wiring Method. Conductors shall be enclosed in raceways or be Type ALS cable or Type MI cable.

Exception No. 1. Bare Conductors. Bare conductors used as contact conductors.

Exception No. 2. Open Conductors. Short lengths of open conductors at resistors, collectors, and other equipment.

Exception No. 3. Flexible Connections. Where flexible connections are necessary to motors and similar equipment, flexible metal conduit, *liquidtight flexible metal conduit, metal-clad cable, multiple conductor rubber-covered cable or an approved nonmetallic enclosure may be employed.*

Exception No. 4. Pendant Push-Button Stations. Where multiple conductor cable is used with a suspended push-button station, the station must be supported in some satisfactory manner that will protect the electrical conductors against strain.

610-12. Raceway Terminal Fittings. Conductors leaving raceways shall comply with the provisions of Section 300-16.

610-13. Types of Conductors. Conductors shall be of the rubber-covered or the thermoplastic type except:

Exception No. 1. Contact Conductors. Contact conductors along runways, crane bridges and monorails may be bare and may be of hard drawn copper, or aluminum, or steel in the form of tees, angles, tee rails, or other stiff shapes.

Exception No. 2. Flexible Conductors. Flexible conductors may be used to convey current and where practicable, cable reels or take-up devices may be employed.

Exception No. 3. Varnished Cambric Conductors. Varnished-cambric conductors (Type V) or asbestos varnished cambric (Types AVA and AVB) may be used in dry locations.

Exception No. 4. Type MI Cable. Type MI cable may be used in wet or dry locations within its specified temperature ratings.

Exception No. 5. Exposed to High Temperatures. Conductors exposed to external heat or connected to resistors shall have an insulation approved for the temperature and location as specified in Section 310-2. Where conductors not having a flame-resistant outer covering are grouped together, the group shall be covered with a flame-resistant tape.

610-14. Conductors

(a) Ampacity. The allowable ampacities of conductors shall be as shown in Table 610-14(a). For the ampacities of conductors between controllers and resistors, see Section 430-23.

(b) Minimum. Conductors shall not be smaller than No. 14.

Exception: No. 16 may be used for crane and hoist motor and control circuits only when the application meets Section 610-14(a) ampacity, and provided the conductors are protected against physical damage.

(c) Contact Conductors. The size of contact wires shall be not less than the following:

Distance between end strain insulators	Size of wire
0-30 feet	No. 6
31-60 feet	No. 4
over 60 feet	No. 2

(d) Calculation of Motor Load. The ampacity of the power supply conductors on the crane shall be not less than the combined short time

Table 610-14(a)

Ampacities of Insulated Conductors in Raceway or Cable Used with Short Time Rated Crane and Hoist Motors

Max. Operating Temp.	60° C		75° C		90° C		110° C	
Size AWG MCM	Type R, RW, T, TW		Type RH, RHW THW, THWN		Type AVB, FEP, FEPB, RHH, SA, TA, THHN		Type AVA	
	60 min	30 min	60 min	30 min	60 min	30 min	60 min	30 min
16	10	10	10	12	..	..	..	..
14	20	20	25	26	31	32	38	40
12	25	25	30	33	36	40	45	50
10	35	35	40	43	49	52	60	65
8	45	50	55	60	63	69	73	80
6	57	70	76	86	83	94	93	105
5	65	80	85	95	95	106	109	121
4	77	95	100	117	111	130	126	147
3	90	115	120	141	131	153	145	168
2	107	130	137	160	148	173	163	190
1	130	150	143	175	158	192	177	215
0	160	180	190	233	211	259	239	294
00	195	225	222	267	245	294	275	331
000	245	280	280	341	305	372	339	413
0000	295	350	300	369	319	399	352	440
250	350	375	364	420	400	461	447	516
300	410	475	455	582	497	636	554	707
350	460	550	486	646	542	716	616	809
400	515	580	538	688	593	760	666	856
450	565	640	600	765	660	836	740	930
500	620	700	660	847	726	914	815	1004

Other insulations shown in Section 310-2 and approved for the temperatures and location may be substituted for those shown in Table 610-14(a).

The allowable ampacities of conductors used with 15-minute motors shall be the 30-minute ratings increased by 12 per cent.

full load ampere rating of the largest motor or group of motors for any single crane motion plus 50 per cent of the combined short time full load ampere rating of the next largest motor or group of motors.

(e) Other Loads. Additional loads, such as heating, lighting, and air conditioning, shall be provided for by application of the appropriate sections of this Code.

610-15. Common Return. Where a crane or hoist is operated by more than one motor, a common-return conductor of proper ampacity may be used.

C. Contact Conductors

610-21. Installation of Contact Conductors. Bare contact conductors shall conform to the following:

(a) Contact Wires. Wires that are used as contact conductors shall be secured at the ends by means of approved strain insulators and shall be so mounted on approved insulators that the extreme limit of displacement of the wire will not bring the latter within less than 1½ inches from the surface wired over.

(b) Supports Along Runways. Main contact conductors carried along runways shall be supported on insulating supports placed at intervals not exceeding 20 feet, and these supports shall be insulating except for grounded rail conductors as provided in Section 610-21(e). Such conductors shall be separated not less than 6 inches except for monorail hoists where a spacing of not less than 3 inches may be used. Where necessary, intervals between insulating supports may be increased up to 40 feet, the separation between conductors being increased proportionately.

(c) Supports on Bridges. Bridge contact conductors shall be kept at least 2½ inches apart and, where the span exceeds 80 feet, insulating saddles shall be placed at intervals not exceeding 50 feet.

It is recommended that the distance between wires be greater than 2½ inches where practicable.

(d) Supports for Rigid Conductors. Conductors along runways and crane bridges, which are of the rigid type specified in Section 610-13 Exception No. 1, shall be carried on insulating supports spaced at intervals of not more than 80 times the vertical dimension of the conductor, but in no case greater than 15 feet, and spaced apart sufficiently to give a clear electrical separation of conductors or adjacent collectors of not less than 1 inch. Hardwood supports covered with, or impregnated with, insulating paint shall be acceptable insulators.

(e) Track as Circuit Conductor. Monorail, tramrail or crane-runway tracks may be used as a conductor of current for one phase of a three-phase alternating-current system furnishing power to the carrier, crane or trolley, provided all of the following conditions are fulfilled:

(1) The conductors for supplying the other two phases of the power supply shall be insulated.

(2) The power for all phases shall be obtained from an insulating transformer.

(3) The voltage shall not exceed 300 volts.

(4) The rail serving as a conductor shall be effectively grounded at the transformer and may also be grounded by the fittings used for the suspension or attachment of the rail to a building or structure.

(f) Electrical Continuity of Contact Conductors. All sections of bare rigid contact conductors shall be mechanically joined to provide a continuous electrical connection.

(g) Not to Supply Other Equipment. Contact conductors shall not be used as feeders for any equipment other than the crane or cranes which they are primarily designed to serve.

(h) Locating or Guarding Contact Conductors. Contact conductors shall be located or guarded in such a manner that unqualified persons cannot inadvertently touch energized current-carrying parts.

610-22. Collectors. Collectors shall be so designed as to reduce to a minimum sparking between them and the contact conductor, and when operated in rooms used for the storage of easily ignitible combustible fibers and materials the requirements of Section 503-13 shall be complied with.

D. Control

610-31. Runway Conductor Disconnecting Means. A disconnecting means shall be provided between the runway contact conductors and the power supply. Such disconnecting means shall consist of a motor-circuit switch or circuit breaker, except that a general-use switch may be used when the disconnecting means is provided in accordance with Section 610-32. This disconnecting means shall be readily accessible and operable from the ground, shall be arranged to be locked in the open position, shall open all ungrounded conductors simultaneously, and shall be placed within sight of the crane or hoist and the runway contact conductors.

610-32. Disconnecting Means for Crane. A motor-circuit switch or circuit breaker shall be provided in the leads from the runway contact conductors on all bridge cranes. Where this disconnecting means is not readily accessible from the crane operating station, means shall be provided at the crane operating station to open the power circuit to the crane motors.

610-33. Rating of Disconnecting Means for Crane. On both alternating-current and direct-current crane protective panels, the continuous ampacity of the switch or circuit breaker required by Section 610-32, and mainline contactors, shall be not less than 50 per cent of the combined short-time ampacities of the motors, nor less than 75 per cent of the sum of the short-time ampacities of the motors required for any single crane motion.

610-34. Limit Switch. A limit switch shall be provided for upper limit of travel of crane hoists.

E. Overcurrent Protection

610-41. Contact Conductors. The main contact conductors shall be protected by an overcurrent device.

610-42. Crane Motors. Where more than one motor is employed on a crane, each motor shall have individual overcurrent protection as provided in Article 430, except that where two motors operate a single hoist, carriage, truck, or bridge, and are controlled as a unit by one controller, the pair of motors with their leads may be protected by a single overcurrent device.

F. Grounding

610-51. Grounding. All exposed metal parts of cranes, hoists, and accessories, including pendant controls, shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded on installation in accordance with Article 250. Moving parts, other than removable accessories or attachments having metal-to-metal bearing surfaces, i.e., such as bridge wheels running on a track, shall be considered to be electrically connected to each other through the bearing surfaces for grounding purposes.

ARTICLE 620 — ELEVATORS, DUMBWAITERS, ESCALATORS, AND MOVING WALKS

A. Scope and General

620-1. Scope. This Article shall apply to electrical equipment and wiring used in connection with elevators, dumbwaiters, escalators, and moving walks.

620-2. Voltage Limitations. The nominal voltage used for elevator, dumbwaiter, escalator, and moving walk operating control and signal circuits, operating equipment, driving machine motors, machine brakes, and motor-generator sets shall not exceed the following:

(a) For operating control and signal circuits and related equipment including door operator motors: 300 volts except that higher potentials may be used for frequencies of 25 through 60 cycles alternating current or for direct current provided the current in the system cannot, under any conditions, exceed 8 milliamperes for alternating current or 30 milliamperes for direct current.

(b) Driving machine motors, machine brakes, and motor-generator sets: 600 volts, except that higher potentials may be used for driving motors of motor-generator sets.

620-3. Live Parts Enclosed. All live parts of electrical apparatus in the hoistways, at the landings, or in or on the cars of elevators and dumbwaiters or in the wellways or the landings of escalators or moving walks shall be enclosed to protect against accidental contact.

B. Conductors

620-11. Insulation of Conductors. The insulation of conductors installed in connection with elevators, dumbwaiters, escalators and moving walks, shall comply with the following:

(a) Control Panel Wiring. Conductors from panels to main circuit resistors shall be flame-retardant and suitable for a temperature of not less than 90°C. (194°F.) All other wiring on control panels shall be flame-retardant, moisture-resistant.

(b) Traveling Cables. Traveling cables used as flexible connections between the elevator or dumbwaiter car and the raceway shall be Type E, EO, or ET elevator cable or other approved types and shall have a flame-retardant, moisture-resistant outer covering.

(c) Other Wiring. All conductors in the raceways and in or on the cars of elevators and dumbwaiters and in the wellways of escalators and moving walks and in the machine room of elevators, dumbwaiters, escalators and moving walks shall have flame-retardant and moisture-resistant insulation.

(d) Thickness of Insulation. The thickness of the insulation of all conductors shall be suitable for the voltage to which the conductors are subjected.

620-12. Minimum Size of Conductors. The minimum size of conductors used for elevator, dumbwaiter, escalator, and moving walk wiring, except for conductors which form an integral part of control equipment, shall be as follows:

(a) Traveling Cables.

(1) For lighting circuits: No. 14, except that No. 20 or larger conductors may be used in parallel provided the ampacity is equivalent to at least that of No. 14 wire.

(2) Operating control and signal circuits: No. 20.

(b) Other Wiring. All operating control and signal circuits: No. 20.

620-13. Motor Circuit Conductors. Conductors supplying elevator, dumbwaiter, escalator, or moving walk motors shall have an ampacity conforming to (a), (b) and (c) below based on the nameplate current rating of the motors. With generator field control, the ampacity shall be based on the nameplate current rating of the driving motor of the motor-generator set which supplies power to the elevator motor.

The heating of conductors depends on root mean square current values which, with generator field control, are reflected by the nameplate current rating of the motor-generator set driving motor rather than by the rating of the elevator motor which represents actual but short time and intermittent full-load current values.

(a) Conductors Supplying a Single Motor. Conductors supplying a single motor shall have an ampacity in conformance with Section 430-22, Table 430-22 (a-Exception).

(b) Conductors Supplying Several Motors. Conductors supplying several motors shall have an ampacity of not less than 125 per cent of the nameplate current rating of the highest rated motor in the group plus the sum of the nameplate current ratings of the remainder of the motors in the group.

(c) Feeder Demand Factor. Feeder conductors of less capacity than required by (b) above may be furnished subject to the requirements of Section 430-26.

C. Wiring

620-21. Wiring Methods. Conductors located in hoistways and escalators and moving walk wellways, in or on cars and machine and control rooms, not including the traveling cables connecting the car and hoistway wiring, shall be installed in rigid conduit, electrical metallic tubing, metal wireways, Type ALS cable or Type MI cable subject to the following exceptions:

Exception No. 1. Flexible conduit or Type AC metal-clad cable may be used in hoistways and in escalator and moving walk wellways between risers and limit switches, interlocks, operating buttons, and similar devices.

Exception No. 2. Short runs of flexible conduit or Type AC metal-clad cable may be used on cars where so located as to be free from oil and if securely fastened in place.

Exception No. 3. Types S, SO, and ST cords may be used as flexible connections between the fixed wiring on the car and the switches on car doors or gates.

Exception No. 4. Conductors between control panels and machine motors, machine brakes, and motor generator sets, not exceeding six feet in length, may be grouped together and taped or corded without being installed in a raceway provided the taping or cording is painted with an insulating paint. Such cable groups shall be supported at intervals of not more than three feet and so located as to be free from physical damage.

Where motor generators and machine motors are located adjacent to or underneath control equipment, and are provided with extra length terminal leads not exceeding six feet in length, such leads may be extended to connect directly to controller terminal studs without regard to the carrying capacity requirements of Articles 430 and 445. Auxiliary gutters may be used in machine and control rooms between controllers, starters and similar apparatus.

D. Installation of Conductors

620-31. Raceway Terminal Fittings. Conductors leaving raceways shall comply with the provisions of Section 300-16. In no case shall the raceway terminate less than 6 inches from the floor.

620-32. Metal Wireways. Section 362-5 shall not apply to wireways. The sum of the cross sectional area of the individual conductors in a metallic wireway shall not be more than 50 per cent of the interior cross sectional area of the wireway.

Vertical runs of wireways shall be securely supported at intervals not exceeding 15 feet and shall have not more than one joint between supports. Adjoining wireway sections shall be securely fastened together to provide a rigid joint.

620-33. Number of Conductors in Other Raceways. The number of operating and control circuit conductors in other raceways may be in accordance with Table 1 of Chapter 9.

620-34. Supports. Supports for Type ALS cable or conductor raceways in the hoistway or escalator or moving walk wellway shall be securely fastened to the guide rail or to the hoistway or wellway construction.

620-35. Auxiliary Gutters (Wiring Troughs). Auxiliary gutters shall not be subject to the restrictions of Section 374-2 as to length or of Section 374-5 as to number of conductors.

620-36. Different Systems in One Raceway or Traveling Cable. Conductors for operating, control, power, signal, and light circuits of 600 volts or less may be run in the same traveling cable or raceway system provided that all conductors are insulated for the maximum voltage found in the cables or raceway system and all live parts of the equipment are insulated from ground for this maximum voltage. Such a traveling cable or raceway may also include a pair of telephone conductors for the car telephone provided such conductors are insulated for the maximum voltage found in the cable or raceway system.

620-37. Foreign Wires. Main feeders for supplying power to elevators and dumbwaiters shall be installed outside the hoistway, except in existing structures subject to special permission of the enforcing authority. Only such electrical wiring, conduit and cable used directly in connection with the elevator or dumbwaiter, including wiring for signals, for communication with the car, for lighting and ventilating the car and wiring for low voltage fire detecting systems for the hoistways, may be installed inside the hoistway.

E. Traveling Cables

620-41. Suspension. Traveling cables shall be so suspended at the car and hoistway end as to reduce the strain on the individual copper conductors to a minimum.

Cables exceeding 100 feet in length and which have steel supporting fillers shall be suspended directly by the steel supporting fillers.

Where nonmetallic fillers are used, the cables shall be suspended by looping the cables around the supports.

620-42. Hazardous Locations. In hazardous locations, traveling cables shall be Type EO and shall be secured to explosion proof cabinets by heavy-duty rubber-bushed threaded connector bushings sealed off at the enclosure as provided in Section 501-5.

620-43. Location of and Protection for Cables. Traveling cable supports shall be so located as to reduce to a minimum the possibility of damage due to the cables coming in contact with the hoistway construction or equipment in the hoistway. Where necessary, suitable guards shall be provided to protect the cables against damage.

F. Control

620-51. Disconnecting Means. There shall be in addition to the elevator controller, a means for disconnecting all conductors of the circuit to the elevator motor, or in the case of generator field control, to the motor of the motor-generator set which supplies current to the elevator motor.

(a) Type. The disconnecting means shall be an enclosed externally operable motor circuit switch or circuit breaker arranged to be locked in the open position.

(b) Location. It shall be located adjacent to and be visible from the elevator machine, unless a disconnect switch in the control circuit of the motor-generator set is placed adjacent to and is visible from the elevator machine.

620-52. Electrical Equipment in Garages and Similar Occupancies. Electrical equipment and wiring used for elevators, dumbwaiters, escalators, and moving walks in garages shall conform to the requirements of Article 511. Wiring and equipment located under the car platform shall be considered as being located in the hazardous area.

620-53. Phase Protection. Elevators driven by polyphase alternating current machine motors shall be provided with means to prevent starting of the elevator motor when:

(a) The phase rotation is in the wrong direction, or

(b) There is a failure in any phase.

G. Overcurrent Protection

620-61. Overcurrent Protection. Overcurrent protection shall be provided as follows:

(a) Control and Operating Circuits. Control and operating circuits and signal circuits shall be protected against overcurrent in accordance with the requirements of Section 725-18.

(b) Motors.

(1) Duty on elevator and dumbwaiter driving machine motors and driving motors of motor generators used with generator field control shall be classed as intermittent. Such motors shall be protected against overcurrent in accordance with Section 430-33.

(2) Duty on escalator and moving walk driving machine motors shall be classed as continuous. Such motors shall be protected against overcurrent in accordance with Section 430-32.

(3) Elevator, dumbwaiter, escalator, and moving walk driving machine motors and driving motors of motor generator sets shall be protected against running overcurrent as provided in Table 430-37, except that no more than two overcurrent protective units shall be required.

H. Machine Room

620-71. Guarding Equipment. Elevator, dumbwaiter, escalator, and moving walk driving machines, motor generator sets, controllers and auxiliary control equipment shall be installed in a space secured against unauthorized access.

Such equipment may be located in rooms or spaces containing other equipment essential to the operation of the building provided it is separated therefrom by a substantial metal grill enclosure of a design which will reject a ball two inches in diameter and is at least six feet high equipped with a self-closing and self-locking door.

It is not intended to prohibit the installation of dumbwaiter, escalator, or moving walk controllers outside the spaces herein specified, provided they are enclosed in cabinets with doors or removable panels capable of being locked in the closed position; nor is it intended to prevent the installation of dumbwaiter controllers within the hoistway without cabinets, provided removable or hinged panels capable of being locked in the closed position are installed in the hoistway enclosures to provide access to the controllers.

620-72. Clearance Around Control Panels. There shall be provided sufficient clear working space around control panels to provide safe and convenient access to all live parts of the equipment necessary for maintenance and adjustment. The minimum clear working space about live parts on control panels shall not be less than set forth in Section 620-72(a and b) unless otherwise specified.

(a) Elevator and Dumbwaiter Panels.

(1) In the front—30 inches to live panel parts.

(2) In the rear—24 inches to live panel parts.

(3) On one side of a panel or a group of panels—18 inches except this clearance can be waived if there is a clear passageway, not less than 18 inches wide at any point, from the front to the rear of the panel or panels.

It shall be permissible to mount control panels on, over or against the hoisting machine or motor generator set or to place auxiliary control equipment in the front or rear of control panels provided the clearances to the live parts are not less than specified and provided there is safe access to the front and/or back of the controller from at least one side.

Where control panels are mounted in cabinets with swing doors or removable panels, sufficient clear space shall be provided to fully open the doors or remove the panels.

(b) Escalator and Moving Walk Control Panels. The minimum working clearance for escalator and moving walk control panels shall be as specified in Section 620-72(a) provided that where the control panel is mounted in the same space as the escalator or moving walk drive machine and the clearances specified cannot be provided, they may be waived where the entire panel is arranged so that it can be readily removed from the machine space and is provided with flexible leads to all external connections.

Where control panels are not located in the same space as the drive machine they shall be so located in cabinets with doors or removable panels capable of being locked in the closed position. Such cabinets may be mounted in the balustrading on the side away from the moving steps or moving treadway.

J. Grounding

620-81. Metal Raceways Attached to Cars. Conduit, Type ALS cable or Type AC metal-clad cable attached to elevator cars shall be bonded to grounded metal parts of the car with which they come in contact.

620-82. Electric Elevators. For electric elevators, the frames of all motors, elevator machines, controllers and the metal enclosures for all electrical devices in or on the car or in the hoistway shall be grounded.

620-83. Nonelectric Elevators. For elevators other than electric, when any electrical conductors are attached to the car, the metal frame of the car, where normally accessible to persons, shall be grounded.

620-84. Hand-Operated Cables. All hand-operated metallic shifting ropes or cables shall be grounded.

620-85. Inherent Ground. Equipment mounted on members of the structural metal frame of a building shall be deemed to be grounded. Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded when the machine is grounded in accordance with Article 250.

K. Overspeed

620-91. Overspeed Protection for DC Elevators. Under overhauling load conditions, means shall be provided on the load side of each elevator power disconnecting means to prevent the elevator from attaining a speed equal to the governor tripping speed or a speed in excess of 125 per cent of the elevator rated speed, whichever is the lesser.

620-92. Motor Generator Overspeed Device. Motor generators driven by direct current motors and used to supply direct current for the operation of elevator machine motors shall be provided with speed limiting devices as required by Section 430-89(c), which will prevent the elevator from attaining at any time a speed of more than 125 per cent of its rated speed.

ARTICLE 630 — ELECTRIC WELDERS

A. General

630-1. Scope. This Article covers electric arc welding, resistance welding apparatus, and other similar welding equipment that is connected to an electrical supply system.

630-2. Other Articles. This Article amplifies or modifies parts of Chapters 1 to 4 inclusive of this Code in order to properly cover the operating conditions to which electric welder installations are subjected. Accordingly, the appropriate provisions of Chapters 1 to 4 inclusive apply to the component parts of electric welder installations except as otherwise provided in this Article.

B. AC Transformer and DC Rectifier Arc Welders

630-11. Ampacities of Supply Conductors. The ampacities of conductors shall be as follows:

(a) Individual Welders. The rated ampacities of the supply conductors shall be not less than the current values determined by multiplying the rated primary current in amperes, given on the welder nameplate, and the following factor based upon the duty cycle or time rating of the welders:

Rated Per Cent Duty Cycle of Welders	Multiplying Factor
20 or less	0.45
30	0.55
40	0.63
50	0.71
60	0.78
70	0.84
80	0.89
90	0.95
100	1.00

For a welder having a time rating of one hour, the multiplying factor shall be 0.75.

(b) Group of Welders. The rated ampacities of conductors which supply a group of welders may be less than the sum of the currents, as determined in accordance with Section 630-11.(a) of the welders supplied. The conductor rating shall be determined in each case according to the welder loading based on the use to be made of each welder and the allowance permissible in the event that all the welders supplied by the conductors will not be in use at the same time. The load value used for each welder shall take into account both the magnitude and the duration of the load while the welder is in use.

Conductor ratings based on 100 per cent of the current, as determined in accordance with Section 630-11(a), of the two largest welders, 85 per cent for the third largest welder, 70 per cent for the fourth largest welder, and 60 per cent for all the remaining welders, should provide an ample margin of safety under high production conditions with respect to the maximum permissible temperature of the conductors. Percentage values lower than those given are permissible in cases where the work is such that a high operating duty cycle for individual welders is impossible.

630-12. Overcurrent Protection. Overcurrent protection shall be as provided in Section 630-12(a and b). Where the nearest standard rating of the overcurrent device used is under the value specified in this Section, or where the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

(a) For Welders. Each welder shall have overcurrent protection rated or set at not more than 200 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having supply conductors protected by an overcurrent device rated or set at not more than 200 per cent of the rated primary current of the welder.

(b) For Conductors. Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 200 per cent of the conductor rating.

630-13. Disconnect Means. A disconnect means shall be provided in the supply connection of each welder which is not equipped with a disconnect mounted as an integral part of the welder.

The disconnect means shall be a switch or circuit breaker and its rating shall be not less than that necessary to accommodate overcurrent protection as specified under Section 630-12.

630-14. Marking. A nameplate giving the following information shall be provided: name of manufacturer; frequency; primary voltage; rated primary current; maximum open-circuit secondary voltage; rated secondary current; basis of rating, i.e., the duty cycle, number of phases, 60-minute rating.

C. Motor-Generator Arc Welders

630-21. Other Sections Which Apply. Motor-generator arc welder installations are covered by the appropriate Sections of Chapters 1 to 4 inclusive applicable to conductors, motors, generators and associated equipment. Referring specifically to the motor supply connections, the following Sections apply in addition to such other provisions as may be applicable. Conductor rating, Sections 430-22 and 430-26. Overcurrent protection for motors, Section 430-33; for conductors, Section 430-52. Controllers, Sections 430-7, 430-8 and 430-83. Disconnecting means, Section 430-111.

D. Resistance Welders

630-31. Ampacities of Supply Conductors. The ampacities of the supply conductors necessary to limit the voltage drop to a value permissible for the satisfactory performance of the welder are usually greater than that required to prevent overheating as prescribed in Section 630-31 (a and b).

(a) Individual Welders. The rated ampacities for conductors for individual welders shall conform to the following:

(1) Varying Operations. The rated ampacities of the supply conductors for a welder which may be operated at different times at different values of primary current or duty cycle shall be not less than 70 per cent of the rated primary current for seam and automatically fed welders, and 50 per cent of the rated primary current for manually operated nonautomatic welders.

(2) Specific Operation. The rated ampacities of the supply conductors for a welder wired for a specific operation for which the actual primary current and duty cycle are known and remain unchanged shall be not less than the product of the actual primary current and the multiplier given below for the duty cycle at which the welder will be operated.

Duty Cycle (per cent)	50	40	30	25	20	15	10	7.5	5.0 or less
Multiplier	.71	.63	.55	.50	.45	.39	.32	.27	.22

(b) Groups of Welders. The rated ampacities of conductors which supply two or more welders shall be not less than the sum of the value obtained as explained in Section 630-31(a) for the largest welder supplied, and 60 per cent of the values obtained as explained in Section 630-31(a) for all the other welders supplied.

(c) Explanation of Terms. (1) The rated primary current is the rated kva multiplied by 1,000 and divided by the rated primary voltage, using values given on the nameplate. (2) The actual primary current is the current drawn from the supply circuit during each welder operation at the particular heat tap and control setting used. (3) The duty cycle is the percentage of the time during which the welder is loaded. For instance, a spot welder supplied by a 60-cycle system (216,000 cycles per hour) making four hundred 15-cycle welds per hour would have a duty cycle of 2.8 per cent (400 multiplied by 15, divided by 216,000, multiplied by 100). A seam welder operating 2 cycles "on" and 2 cycles "off" would have a duty cycle of 50 per cent.

630-32. Overcurrent Protection. Overcurrent protection shall be as provided in Section 630-32(a and b). Where the nearest standard rating of the overcurrent device used is under the value specified in this Section, or where the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

(a) For Welders. Each welder shall have an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having a supply circuit protected by an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder.

(b) For Conductors. Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 300 per cent of the conductor rating.

630-33. Disconnecting Means. A switch or circuit breaker shall be provided by which each welder and its control equipment can be isolated from the supply circuit. The ampacity of this disconnecting means shall be not less than the supply conductor rating determined as explained in this Article. The supply circuit switch may be used as the welder disconnecting means where the circuit supplies only one welder.

630-34. Marking. A nameplate giving the following information shall be provided: name of manufacturer, frequency, primary voltage, rated kva at 50 per cent duty cycle, maximum and minimum open-circuit secondary voltage, short-circuit secondary current at maximum secondary voltage and specified throat and gap setting.

ARTICLE 640 — SOUND-RECORDING AND SIMILAR EQUIPMENT

640-1. Scope. This Article shall apply to installations of equipment and wiring used for sound-recording and reproduction, centralized distribution of sound, public address, speech-input systems and electronic organs.

640-2. Application of Other Articles.

(a) Except as modified by this Article, wiring and equipment from source of power to and between devices connected to the interior wiring systems shall comply with the requirements of Chapters 1 to 4, inclusive, of this Code.

(b) Wiring and equipment for public-address, speech-input, radio-frequency, audio-frequency systems, and amplifying equipment associated with radio receiving stations in centralized distribution systems, shall comply with Article 725.

640-3. Number of Conductors in Raceway. The number of conductors in a conduit or other raceway shall comply with Tables 1 to 7 inclusive of Chapter 9 except as follows:

Exception No. 1. Special permission may be granted for the installation of two 2-conductor lead-covered cables in ¾-inch conduit, provided the cross-sectional area of each cable does not exceed .11 square inch.

Exception No. 2. Special permission may be granted for the installation of two 2-conductor No. 19 lead-covered cables in ½-inch conduit, provided the sum of the cross-sectional areas of the cables does not exceed 32 per cent of the internal cross-sectional area of the conduit.

640-4. Wireways and Auxiliary Gutters.

(a) Wireways and auxiliary gutters shall comply with the requirements of Articles 362 and 374.

(b) Where used for sound-recording and reproduction the following exceptions are made:

Exception No. 1. Number of Conductors in Raceway. Conductors in wireways or gutters shall not fill the raceway to more than 75 per cent of its depth.

Exception No. 2. Auxiliary-Gutter Covers. Where the cover of auxiliary gutters is flush with the flooring and is subject to the moving of heavy objects it shall be of steel at least ¼ inch in thickness; where not subject to moving of heavy objects, as in the rear of patch or other equipment panels, the cover shall be at least No. 10 USS gage (0.1345 inch).

Exception No. 3. Metal-Trough Raceways. Metal-trough raceways may be installed in concealed places provided they are run in a straight line between outlets or junction boxes. Covers of boxes must be accessible. Edges of metal must be rounded at outlet or junction boxes and all rough projections smoothed to prevent abrasion of insulation or conductors. Raceways made of sections shall be bonded and grounded as prescribed in Section 250-76.

Exception No. 4. Grounding Wireways and Auxiliary Gutters. Metal wireways and auxiliary gutters shall be grounded in accordance with the requirements of Article 250. Where the wireway or auxiliary gutter does not contain power supply wires, the grounding conductor need not be larger than No. 14 copper or its equivalent. Where the wireway or auxiliary gutter contains power supply wires, the grounding conductor shall not be smaller than the size called for in Section 250-95.

640-5. Conductors. Amplifier output circuits carrying audio-program signals of 70 volts or less and whose open circuit voltage will not exceed 100 volts, may employ Class 2 wiring as covered in Article 725.

The above is based on amplifiers whose open-circuit voltage will not exceed 100 volts when driven with a signal at any frequency from 60 to 100 cps sufficient to produce rated output (70.7 volts) into its rated load. This also accepts the known fact that the average program material is 12 db below the amplifier rating—thus the average RMS voltage for an open-circuit 70 volt output would be only 25 volts.

640-6. Grouping of Conductors. Conductors of different systems grouped in the same conduit or other metallic enclosure, or in portable cords or cables, shall comply with the following requirements:

(a) Power-Supply Conductors. Power-supply conductors shall be properly indicated and shall be used solely for supplying power to the equipment to which the other conductors are connected.

(b) Leads to Motor-Generator or Rotary Converter. Input leads to a motor-generator or rotary converter shall be run separately from the output leads.

(c) Conductor Insulation. The conductors shall be insulated individually, or collectively in groups, by insulation at least equivalent to that on the power-supply and other conductors.

Exception: Where the power-supply and other conductors are separated by a lead sheath or other continuous metallic covering.

640-7. Flexible Cords. Flexible cords and cables shall be of types P, K, S, SJ, ST, SJO, and SJT or other types specifically approved for the purpose for which they are to be used. The conductors of flexible cords, other than power-supply conductors, may be of a size not smaller than No. 26 provided such conductors are not in direct electrical connection with the power-supply conductors and are equipped with current-limiting means so that the maximum power under any condition will not exceed 150 watts.

640-8. Terminals. Terminals shall be marked to show their proper connections. Terminals for conductors other than power-supply conductors shall be separated from the terminals of the power-supply conductors by a spacing at least as great as the spacing between power-supply terminals of opposite polarity.

640-9. Storage Batteries. Storage batteries shall comply with the following:

(a) Installation. Storage batteries shall be installed in accordance with Article 480.

(b) Conductor Insulation. Storage-battery leads shall be rubber-covered or thermoplastic-covered.

640-10. Overcurrent Protection of "A", "B" and "C" Circuits. Overcurrent protection shall be provided as follows:

(a) "A" circuit, where supplied by branch-lighting circuits, or by storage batteries of more than 20-ampere-hour capacity, shall have overcurrent protection not exceeding 15 amperes.

(b) "B" circuits shall have overcurrent protection not exceeding one ampere. The overcurrent protection shall be placed in each positive lead.

(c) "C" circuits where supplied from branch lighting circuits or from storage batteries of more than 20 ampere-hour capacity shall have overcurrent protection not exceeding one ampere.

(d) Overcurrent devices shall be located as near as practicable to the battery.

640-11. Amplifiers and Rectifiers—Type.

(a) They shall be suitably housed and shall be of a type approved for the purpose unless otherwise expressly permitted by the authority enforcing this Code.

(b) Amplifiers and rectifiers shall be so located as to be readily accessible.

(c) Amplifiers and rectifiers shall be so located as to provide sufficient ventilation to prevent undue temperature rise within the housing.

640-12. Hazardous Locations. Equipment used in hazardous locations shall be specifically approved for the purpose.

640-13. Protection Against Physical Damage. Amplifiers, rectifiers, loud-speakers and other equipment shall be so located or protected as to guard against physical damage such as might result in fire or personal hazard.

ARTICLE 650 — ORGANS

650-1. General. This Article shall apply to those electric circuits and parts of electrically operated organs which are employed for the control of the sounding apparatus and keyboards. Electronic organs shall comply with the appropriate provisions of Article 640.

650-2. Source of Energy. The source of energy shall have a potential of not over 15 volts and shall be a self-excited generator, a two-coil transformer type rectifier or a primary battery.

650-3. Insulation—Grounding. The generator shall be effectively insulated from the ground and from the motor driving it, or both the generator and the motor frames shall be grounded in the manner prescribed in Article 250.

650-4. Conductors. Conductors shall comply with the following:

(a) Size. No conductor shall be smaller than No. 26, and the common-return conductor shall be not smaller than No. 14.

(b) Insulation. Conductors shall have rubber, thermoplastic, asbestos, cotton, or silk insulation, except the common-return conductor which shall be rubber-covered, thermoplastic, asbestos-covered (types AA, AI, or AIA), or slow-burning (type SB). The cotton or silk may be saturated with paraffin if desired.

(c) Conductors to Be Cabled. Except the common-return conductor, and conductors inside the organ proper, the organ sections and the organ console, conductors shall be cabled. The common-return conductor may be placed under an additional covering enclosing both cable and return conductor, or may be installed as a separate conductor and may be in contact with the cable.

(d) Cable Covering. The cable shall be provided with one or more braided outer coverings, provided that a tape may be used in place of an inner braid. Where not installed in metal raceways the outer braid shall be flame-retardant or shall be covered with a closely-wound fireproof tape.

650-5. Installation of Conductors. Cables shall be securely fastened in place and may be attached directly to the organ structure without insulating supports. Cables shall not be placed in contact with other conductors.

650-6. Overcurrent Protection. Circuits shall be so arranged that all conductors, except the main supply conductors and the common-return conductor, shall be protected from overcurrent by an overcurrent device of not greater than 15-ampere rating.

ARTICLE 660 — X-RAY EQUIPMENT

A. Scope and Installation

660-1. Scope. The provisions of this Article shall apply to all X-ray equipment operating at any frequency or voltage for medical or industrial use, or for any other purpose.

Nothing in this Article shall be construed as specifying safeguards against the useful beam or stray X-ray radiation.

Recommendations for radiation protection by the National Committee on Radiation Protection and Measurement are published as National Bureau of Standards Handbooks obtainable from Superintendent of Documents, Washington 25, D.C.

660-2. Hazardous Locations or 600 Volt Supply. Unless approved for the location, X-ray and related equipment shall not be installed or operated in hazardous locations or operated on a supply potential of more than 600 volts.

660-3. Connection to Supply Circuit.

(a) Stationary Equipment. X-ray equipment permanently installed shall be connected to the power supply by means of a wiring method meeting the general requirements of this Code, except that equipment properly supplied by branch circuits not larger than a 30-ampere branch circuit may be supplied through suitable plug and hard service cable or cord.

(b) Portable and Transportable. Individual branch circuits shall not be required for portable X-ray equipment requiring a capacity not exceeding 50 amperes. Portable type X-ray equipment of any capacity shall be supplied through a suitable plug and hard service cable or cord.

Transportable X-ray equipment of any capacity may be connected to its power supply by suitable temporary connections and hard service cable or cord.

660-4. Disconnecting Means. A disconnecting means of adequate capacity for at least 50 per cent of the input required for the momentary rating of the X-ray equipment shall be provided in the supply circuit and it shall be operable from a location readily accessible from the X-ray control. For equipment requiring 125 volt line fuses of 30 ampere or less, a plug and receptacle of proper size and of an approved make may serve as a disconnecting means. Disconnecting means shall not be required for portable X-ray equipment of any capacity which complies with section 660-11.

Definitions:

Continuous rating. Continuous rating is a constant load which can be carried for an indefinite period of time.

Long time rating. A long time rating is the rating based on an operating interval of 5 minutes or longer.

Momentary rating. A momentary rating is the rating based on an operating interval that does not exceed 5 seconds.

660-5. Branch Circuit and Overcurrent Protection Requirements. Fifty per cent of the momentary rating of the X-ray equipment shall be used in determining the ampacity requirements for branch circuits and overcurrent protection devices.

The ampacities of the branch circuit conductors and the ratings of disconnecting means and overcurrent protection for X-ray equipment is usually recommended by the manufacturer for the specific installation.

660-6. Wiring Terminals. Unless provided with a permanently attached cord or a cord set, X-ray equipment shall be provided with suitable wiring terminals or leads for the connection of conductors of at least the size required by the input load corresponding to the long time rating of the equipment.

660-7. Number of Conductors in Raceway. The number of control circuit conductors installed in a raceway may be in accordance with Table 1 of Chapter 9.

660-8. X-ray Installations.

(a) Shockproof Installations. All new equipment used on new installations of X-ray equipment, or used or reconditioned equipment moved to and reinstalled at a new location, shall be of the approved shockproof type, except as provided for in Section 660-8(b). All controls, tables, X-ray tube stands, transformer tanks, shockproof cables, and X-ray tube heads, etc. shall be suitably grounded to prevent accidental shock to patient or operator.

(b) Nonshockproof Re-installations. No nonshockproof X-ray equipment shall be reinstalled in a new location without special permission from the authority enforcing this Code. Any such equipment shall be reinstalled in an approved manner.

660-9. On Fluoroscopic Tables. Where permitted in accordance with Section 660-8(b), leads on fluoroscopic tables shall be adequately insulated or be provided with barriers which will guard against inadvertent contact.

B. Control

660-10. Stationary Equipment. A manually controlled device shall be incorporated in the X-ray control supply or in the primary circuit to the high voltage transformer, and shall be adequate to control the load resulting from failures in the high voltage circuit. This device shall be a part of the X-ray equipment, but may be located in a separate enclosure immediately adjacent to the X-ray control unit.

660-11. Portable Equipment. Portable equipment shall comply with Section 660-10, but the manually controlled device shall be located in or on the equipment.

660-12. General.

(a) Radiographic Type. There shall be provided a timer or automatic exposure terminating device and also a switch of a type which opens automatically except when held closed by the operator.

(b) Fluoroscopic Type. A switch shall be provided which shall be designed to open automatically except when held closed by the operator.

(c) Therapy. A timer or automatic exposure terminating device shall be provided which is not of the repeating type.

C. Industrial Apparatus

660-13. Industrial X-ray Apparatus.

(a) Radiographic and Fluoroscopic Types. A switch which shall be designed to open automatically except when held closed by the operator, or a timer, shall be provided except on equipment or installations effectively enclosed or provided with interlocks to prevent ready access to live current-carrying parts during operation.

(b) Industrial or Laboratory Apparatus — Diffraction or Irradiation Types. Positive indication of energization by pilot lights, readable meter deflections or equivalent means shall be provided except on equipment or installations effectively enclosed or provided with interlocks to prevent ready access to live current-carrying parts during operation.

660-14. Independent Control. Where more than one piece of apparatus is operated from the same high-voltage circuit, each piece or each group of apparatus as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by persons with its live parts.

D. Transformers and Capacitors

660-15. General. Transformers and capacitors which are part of an X-ray apparatus shall not be required to conform to the requirements of Articles 450 and 460 of this Code.

660-16. Draining Capacitor Charge. Capacitors shall be provided with an automatic means for discharge and grounding the plates whenever the transformer primary is disconnected from the source of supply.

Exception No. 1. Where all current-carrying parts of capacitors, and of the conductors connected therewith, are at least 8 feet from the floor and are inaccessible to unauthorized persons.

Exception No. 2. Where within 8 feet from the floor are within enclosures of grounded metal or insulating material.

E. Guarding and Grounding

660-17. General.

(a) High Voltage Parts. All high voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Either air, oil, gas or other suitable insulating media may be used to insulate the high voltage from the grounded enclosure. The connections from the high voltage equipment to X-ray tubes and other high voltage components shall be made with high voltage cables of the shockproof type.

(b) Low Voltage Cables. Low voltage connecting cables to oil filled units such as transformers, condensers, oil coolers, and high voltage switches which are not completely sealed shall be of the oil resistant type.

660-18. Grounding. Noncurrent-carrying metal parts of tube stands, fluoroscopic and other equipment shall be grounded in the manner prescribed in Article 250.

(a) Portables. Portable equipment shall be provided with an approved grounding type plug.

ARTICLE 665 — INDUCTION AND DIELECTRIC HEATING EQUIPMENT

A. Scope and General

665-1. Scope. The provisions of this Article shall apply to the construction and installation of induction and dielectric heating equipment and accessories for industrial, scientific and medical applications, but not for appliances.

665-2. Definitions. The term "heating equipment" as used in this Article includes any equipment used for heating purposes whose heat is generated by induction or dielectric methods.

Induction heating is the heating of a nominally conducting material due to its own I^2R losses when the material is placed in a varying electromagnetic field.

Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

The term "therapeutic high frequency equipment" as used in this Article shall be understood to mean generating equipment capable of producing alternating currents having frequencies greater than those frequencies which elicit neuromuscular response. In order to comply with the above, the output frequency of the therapeutic high frequency equipment shall not be less than 2 megacycles.

665-3. Application of Other Articles. Wiring from the source of power to the heating equipment shall comply with the Code Chapters 1 to 4 inclusive. Circuits and equipment operating on a supply circuit of more than 600 volts shall comply with the provisions of Article 710.

665-4. Hazardous Locations. Induction and dielectric heating equipment shall not be installed in hazardous locations as defined in Article 500 unless the equipment and wiring is designed and approved for the locations.

B. Motor-Generator Equipment

665-5. Scope. Motor generator equipment shall include all rotating equipment designed to operate from an AC or DC motor, or by mechanical drive from a prime mover, producing an alternating current of any frequency for induction and/or dielectric heating.

665-6. Ampacities of Supply Conductors. Ampacities of supply conductors shall be determined by Article 430 of this Code.

665-7. Overcurrent Protection. Overcurrent protection shall be provided as specified in Article 430 of this Code for the electrical supply circuit.

665-8. Disconnecting Means. The disconnecting means shall be provided as specified in Article 430 of this code.

A readily accessible disconnecting means shall be provided by which each heating equipment can be isolated from the supplying circuit. The ampacity of this disconnecting means shall be not less than the nameplate current rating of the equipment. The supply circuit disconnect means may be used as a heating equipment disconnecting means where the circuit supplies only one equipment.

665-9. Output Circuit Definition. The output circuit shall include all high frequency output components external to the generator, including contactors, transformers, bus-bars, and transmission lines. The same definition shall apply to all off line frequencies obtained from motor generators, or generators used with induction heating loads.

665-10. Output Circuits. Output circuits shall conform to the following:

(a) Generator Output. The output circuit shall be isolated from ground, except for the capacitive coupling inherent in the generator, which, in effect causes the generator terminals to have voltages from terminal to ground that are equal.

When rated at more than 500 volts, the output circuit shall incorporate a DC ground protector unit. The DC impressed on the output circuit shall not exceed 30 volts and shall not exceed a current capability of 5 milliamperes.

An isolating transformer for matching the load and the source may be used in the output circuit wherein the secondary is not at DC ground potential.

(b) Component Interconnections. The various components required for a complete induction heating equipment installation shall be connected by properly protected multiconductor cable, bus bar, or coaxial cable. Cables shall be installed in non-ferrous conduit raceways. Bus bar shall be protected where required by nonferrous enclosures.

665-11. Control-Enclosures. Low frequency AC or DC may be used in the control portion of the heating equipment. This shall be limited to a value of 150 volts. Solid or stranded wire, properly sized in No. 18 AWG or larger shall be used. Sixty cycle components may be used to control HF when properly rated by the induction heating equipment manufacturer. Electronic circuits utilizing solid state devices and tubes may use printed circuits or wire sizes, properly sized smaller than No. 18 AWG.

665-12. Remote Control

(a) When remote controls are used for applying power, a "Local-Remote" switch shall be provided and interlocked so as to prevent the possibility of applying power from other than one selected control point or points.

(b) Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing.

C. Equipment Other Than Motor Generator

665-13. Scope. Equipment other than motor generator includes all static multipliers and oscillator type units utilizing vacuum tubes and/or solid state devices. The equipment shall be capable of converting AC, or DC to a frequency suitable for induction and/or dielectric heating.

665-14. Ampacities of Supply Conductors. Ampacities of supply conductors shall be determined as follows:

(a) The ampacity of the circuit shall be not less than the nameplate current rating of the equipment.

(b) The ampacities of conductors supplying two or more equipments shall be not less than the sum of nameplate current ratings on all equipment except as follows: Where, when supplying two or more equipments from the same feeder, simultaneous operation of said equipments is not possible, the ampacity of the feeder shall be not less than the sum of the nameplate currents for the largest group of machines capable of simultaneous operation, plus 100 per cent of the standby currents of the remaining machines supplied.

665-15. Overcurrent Protection. Overcurrent protection shall be provided as specified in Article 430 for the equipment as a whole. This overcurrent protection shall be provided separately or as a part of the equipment.

665-16. Disconnecting Means. A readily accessible disconnecting means shall be provided by which each heating equipment can be isolated from the supplying circuit. The ampacity of this disconnecting means shall not be less than the nameplate current rating of the equipment. The supply circuit disconnect means may be used for disconnecting the heating equipment where the circuit supplies only one equipment.

665-17. Output Circuit Definition. The output circuit shall include all high frequency output components external to the converting device including contactors, transformers, bus-bars, and transmission lines. The same definition shall apply to all off line frequencies obtained from the converting device, or devices used with induction and/or dielectric heating loads.

665-18. Output Circuits. Output circuits shall conform to the following:

(a) Converter output. The output circuit (direct or coupled) shall be at DC ground potential.

(b) Converter and Applicator Connection. When the connections between the converter and the work applicator exceed two feet in length the connections shall be enclosed or guarded with noncombustible material.

665-19. Line Frequency in Converter Equipment Output. Commercial frequencies of 25 to 60 cycle alternating current output may be coupled for control purposes, but shall be limited to a value of 150 volts available only during periods of circuit operation.

665-20. Keying. Where high-speed keying circuits dependent on the effect of "oscillator blocking" are employed, the peak R.F. output voltage during the blocked portion of the cycle shall not exceed 100 volts in units employing R.F. converters.

665-21. Remote Control.

(a) When remote controls are used for applying power, a "Local Remote" switch shall be provided and interlocked so as to prevent the possibility of applying power from other than one selected control point or points.

(b) Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing.

D. Guarding and Grounding

665-22. Enclosures. The converting apparatus (including the DC line) and high frequency electrical circuits (excluding the output circuits and remote control circuits), shall be completely contained in an enclosure or enclosures of noncombustible material.

665-23. Panel Controls. All panel controls shall be of "dead front" construction.

665-24. Access to Internal Equipment. Doors or detachable panels may be employed for internal access. Where doors are used giving access to voltages from 500 to 1000 volts AC or DC, either door locks shall be provided or interlocking shall be installed with the choice of precaution optional. Where doors are used giving access to voltages above 1000 volts AC or DC, either mechanical lockouts, with a disconnect means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks shall be provided. Detachable panels not normally used for access to such parts shall be fastened in a manner which will make them inconvenient to remove.

665-25. Warning Labels. "Danger" labels shall be attached on the equipment, and shall be plainly visible even when doors are opened or panels are removed from compartments containing voltages above 250 volts AC or DC.

665-26. Capacitors. When capacitors in excess of 0.1 Mfd. are used in DC circuits, either as rectifier filter components, or suppressors, etc., having circuit voltages exceeding 230 volts above ground, bleeder resistors or grounding switches shall be used as grounding devices. The time of discharge shall be in accordance with Article 460-6.(a).

Where auxiliary rectifiers are used with filter capacitors in the output for bias supplies, tube keyers, etc., bleeder resistors shall be used even though the DC voltage may not exceed 230 volts.

665-27. Work Applicator Shielding. Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils may be protected by insulation and/or refractory materials. Interlock switches shall be used on all hinged access doors, sliding panels or other easy access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels are not required when the applicator is an induction heating coil at DC ground potential or operating at less than 150 volts AC.

665-28. Grounding and Bonding. Grounds and/or inter-unit bonding shall be used wherever required for circuit operation and for limiting to a safe value radio frequency potentials between all exposed noncurrent-carrying parts of the equipment and earth ground, also between all equipment parts and surrounding objects and between such objects and earth ground. Such grounding and bonding shall be installed in accordance with Article 250 of this Code.

665-29. Marking. Each heating equipment shall be provided with a nameplate, giving the manufacturer's name and model identification, and the following input data: line volts, frequency, number of phases, maximum current, full load KVA and full load power factor.

E. Therapeutic Equipment

665-30. Installation.

(a) Where portability is not essential, equipment shall be permanently installed in accordance with Chapters 1 to 3 inclusive of this Code.

(b) Where portability is essential, the power supply cord shall be a three-conductor hard service type with an ampacity not less than the marked rating of the equipment. One conductor having a continuous green color or a continuous green color with a yellow stripe insulation shall be used solely for equipment grounding. The cord shall terminate in an approved grounding attachment-plug cap as described in Section 250-59.(b).

665-31. Applicators for Therapeutic Equipment. Application of the high frequency power to the patient may be made by means of an electric field or of an induction field. Current-carrying parts of applicators shall be so insulated or enclosed that reliable isolation of the patient shall be assured.

665-32. Enclosure. The converting apparatus including the DC line, and high frequency electrical circuits, but excluding the line cord for portable units and the output circuits, shall be contained in an enclosure of noncombustible material.

665-33. Panel Controls. All panel controls shall be of "dead front" construction.

665-34. Access to Internal Equipment. Access shall be through panels not conveniently removable. Panels which need removal for access to fuses, tubes, adjustments, overload reset devices, internal top switches, and the like, shall be labeled to indicate danger if and when removed, or shall be provided with suitable electrical interlock devices.

ARTICLE 670 — METALWORKING MACHINE TOOLS

For further information see NFPA Standard on Metalworking Machine Tools (No. 79).

670-1. Scope. The provisions of this Article apply to the size and overcurrent protection of supply conductors to metalworking machine tools and to the nameplate data required on each such tool.

670-2. Definition of Metalworking Machine Tools. For the purpose of this Article, metalworking machine tools are defined as follows:

(a) A metal-cutting machine tool is a power driven machine, not portable by hand, used for the purpose of removing metal.

(b) A metal-forming machine tool is a power driven machine, not portable by hand, used to press, forge, emboss, hammer, blank, or shear metal.

670-3. Machine Tool Nameplate Data. A permanent nameplate listing supply voltage, phase, frequency, full load currents (see note), ampere rating of largest motor, short circuit interrupting capacity of the machine overcurrent protective device if furnished, and diagram number shall be attached to the control equipment enclosure or machine where plainly visible after installation.

NOTE 1. The full load current shall be not less than the sum of the full load currents required for all motors and other equipment which may be in operation at the same time under normal conditions of use. Where unusual type loads, duty-cycles, etc., require oversized conductors, the required capacity shall be included in the marked "full load current."

NOTE 2. Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.

670-4. Conductors Supplying a Machine Tool.

(a) The supply circuit conductor shall have an ampacity of not less than the marked full load current rating plus 25 per cent of the full load current rating of the highest rated motor as indicated on the nameplate. For the protection of supply conductors to the machine tool, refer to Section 240-5.

(b) A machine tool conforming with NFPA No. 79 shall be considered individual unit equipment. It is provided with a disconnecting means and may be supplied by branch circuits protected by either fuses or circuit breakers.

(c) The disconnecting means may or may not incorporate overcurrent protection. Where the machine tool nameplate is marked "Overcurrent protection provided at machine supply termials," the supply conductors are to be considered either as feeders, or taps as covered by Section 240-15.

"Overcurrent protection provided at machine supply terminals" means that provision has been made in the machine tool for each set of supply conductors to terminate in a single circuit breaker or set of fuses.

ARTICLE 680 — SWIMMING POOLS

680-1. Scope. The provisions of this Article apply to the construction and installation of electric wiring for equipment in or adjacent to swimming pools, to metallic appurtenances in or within 5 feet of the pool, and to the auxiliary equipment such as pumps, filters and similar equipment. No electric appliances or wiring shall be installed in the water or in the enclosing walls of a swimming pool, except as provided for in this Article.

680-2. Approval of Equipment. All equipment shall be approved for the purpose.

680-3. Application of Other Articles. Except as modified by this Article, wiring and equipment in or adjacent to swimming pools shall comply with the applicable requirements of Chapters 1 to 4, inclusive, of this Code.

See Article 720 for low voltage lighting.

680-4. Lighting.

(a) The provisions of this Section apply to lighting fixtures installed below the pool surface.

(b) No lighting fixture shall be installed for operation at more than 150 volts.

(c) A nonmetallic fixture shall not be used with a grounded power supply.

(d) All noncurrent carrying metal parts of lighting fixtures shall be grounded whether exposed or enclosed in nonconducting materials. The fixture shall be secured and grounded to the forming shell by a positive locking device which will assure a low resistance contact and which will require a tool to remove the fixture from the forming shell.

Definition. A forming shell is a metal housing designed to contain a lighting fixture assembly for mounting into a swimming pool structure. The forming shell provides a bond between the raceway and the non-current carrying metal parts of the fixture.

(e) Fixtures approved for the purpose may be installed outside the walls of the pool in closed recesses which are adequately drained and accessible for maintenance.

(f) Approved metal fixture housings (forming shells) shall be installed for the mounting of all wet niche underwater fixtures and shall be equipped with provisions for threaded conduit entries. Metal parts of the fixtures and fixture housings in contact with the pool water and the supply conduit below grade level shall be of brass or other approved corrosion-resistant metal. The rigid conduit shall extend from the fixture housing (forming shell) to a suitable junction box located as provided in Section 680-5 of this Article.

(g) Underwater lighting fixtures shall perform reliably under any likely combination of fault conditions so that there is no shock hazard. Compliance with this requirement shall be assured by one of the following:

(1) The design and construction of the fixtures; or

(2) The use of differential type circuit protection; or

(3) The use of a transformer complying with Section 680-4(h) and further provided with a ground detector if the circuit voltage is greater than 15 volts; or

(4) Other acceptable means.

(h) Transformers used for the supply of fixtures, together with the transformer enclosure, shall be approved for the purpose. The transformers shall be a two-winding type having a grounded metal barrier between the primary and secondary voltage windings.

(i) Within the fixture the cord termination, all splices, and the ground connection shall be covered with a suitable compound to protect them from the deteriorating effect of exposure to pool water in the event of a failure causing water to enter the fixture.

680-5. Junction Boxes and Transformer Enclosures.

(a) Junction boxes installed on the supply side of conduits extending to underwater pool lights shall be provided with threaded hubs for conduit connection. These boxes shall be located not less than 8 inches above ground, pool deck, or maximum pool water level, whichever provides the greatest elevation, nor less than 4 feet from the perimeter of the pool unless part of an approved fixture assembly. Junction boxes mounted above the grade of the finished walkway around the pool shall not be located in the walkway unless afforded additional protection such as by location under diving boards, adjacent to fixed structures, and the like.

(b) Transformer enclosures shall be located not less than 12 inches above ground, pool deck, or maximum pool water level, whichever provides the greatest elevation, nor less than 4 feet from the perimeter of the pool. Transformer enclosures mounted above the grade of the finished walkway around the pool shall not be located in the walkway unless afforded additional protection such as by location under diving boards, adjacent to fixed structures, and the like.

(c) Boxes shall be provided with means for independently terminating not less than two grounding conductors.

680-6. Attachment Plug Receptacles. No attachment plug receptacles shall be installed within 10 feet of the inside walls of the swimming pool.

Exception. Attachment plug receptacles of other than the standard 15 ampere parallel slot type may be installed where an integral part of the lighting fixture assembly and where used for the installation, maintenance, or servicing of the fixture.

NOTE: In determining the 10-foot dimension, the distance to be measured is the shortest path which the supply cord of an appliance connected to the receptacle would follow without piercing a building floor, wall or ceiling.

680-7. Grounding.

(a) All metallic conduit, piping systems, pool reinforcing steel, lighting fixtures, lighting fixture housings, metal parts of ladders, diving boards and their supports, and the like shall be bonded together and grounded to a common ground. The bonding conductor shall be not smaller than No. 8 copper.

Exception: The usual steel tie wires are considered suitable for bonding the reinforcing steel together and welding or special clamping will not be required.

(b) An unbroken No. 12 AWG, or larger, insulated copper wire shall be provided for a grounding conductor from the junction box to the distribution panel ground. This conductor shall be installed in rigid metallic conduit with the circuit conductors from the pool junction box to the distribution panel ground terminal.

(c) Metallic raceways shall not be depended upon for grounding. Where exposed to pool water and in other corrosive areas such as in pump houses or adjacent to water treating and other equipment, the grounding of the non-current carrying parts shall be by means of an insulated copper conductor sized in accordance with Section 250-95 and not smaller than No. 12 AWG.

680-8. Methods of Grounding and Bonding.

(a) Metal wiring enclosures shall be grounded in accordance with Article 250, in addition to other requirements of this Article.

(b) In addition to other requirements of this Article, lighting fixtures that are supplied by flexible cord or cable shall have all metal parts grounded by means of an insulated grounding conductor that is an integral part of the cord or cable. This grounding conductor shall be connected to a grounding terminal in the supply junction box. This conductor shall be equal in size to the supply conductors but not smaller than No. 16 AWG.

(c) Nonelectrical equipment shall be grounded to a common ground in accordance with Section 680-7.

Structural reinforcing steel may be used as a common bonding conductor for nonelectrical parts where connections can be made in accordance with Section 250-113.

680-9. Clearances. Service drop conductors and any other open overhead wiring shall not be installed above the swimming pool or surrounding area extending 10 feet horizontally from the pool edge, or diving structure, observation stands, towers or platforms.

See Section 90-2(b).

Chapter 7. Special Conditions

ARTICLE 700 — EMERGENCY SYSTEMS

A. General

700-1. Scope. The provisions of this Article apply to the installation, operation and maintenance of circuits, systems and equipment intended to supply illumination and power in the event of failure of the normal supply or in the event of accident to elements of a system supplying power and illumination essential for safety to life and property where such systems or circuits are legally required by Municipal, State, Federal or other Codes, or by any governmental agency having jurisdiction.

Emergency systems are generally installed in places of assembly where artificial illumination is required, such as buildings subject to occupancy by large numbers of persons, hotels, theaters, sports arenas, hospitals and similar institutions. Emergency systems may provide power for such functions as essential refrigeration, operation of mechanical breathing apparatus, ventilation when essential to maintain life, illumination and power for hospital operating rooms, fire alarm systems, fire pumps, industrial processes where current interruption would produce serious hazards, public address systems and similar functions.

See NFPA Building Exits Code (NFPA No. 101) for specification of locations where emergency lighting is considered essential to life safety.

700-2. Other Requirements.

All requirements of the MASSACHUSETTS ELECTRICAL Code shall apply to emergency systems, except as modified by this article.

700-3. Equipment Approval. All equipment shall be approved for use on emergency systems.

700-4. Tests and Maintenance.

(a) The authority having jurisdiction shall conduct or witness a test on the complete system upon installation and periodically afterward.

(b) Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to assure their maintenance in proper operating condition.

(c) Where battery systems or unit equipments are involved, including batteries used for starting or ignition in auxiliary engines, the authority having jurisdiction shall require periodic maintenance.

(d) A written record shall be kept of such tests and maintenance.

700-5. Capacity. Emergency systems shall have adequate capacity and rating for the emergency operation of all equipment connected to the system.

B. Sources of Power

700-6. Systems. Current supply shall be such that in event of failure of the normal supply to or within the building or group of buildings concerned, emergency lighting, or emergency power, or both emergency lighting and power, will be immediately available. The supply system for emergency purposes may comprise one or more of the types of system covered in Section 700-7 to Section 700-10. Unit equipments in accordance with Section 700-22 shall satisfy the applicable requirements of this Article.

Consideration must be given to the type of service to be rendered, whether of short time duration, as for exit lights of a theater, or of long duration as for supplying emergency power and lighting due to a long period of current failure from trouble either inside or outside the building, as in the case of a hospital.

Assignment of degree of reliability of the recognized emergency supply system depends upon the careful evaluation of the variables at each particular installation.

700-7. Storage Battery. One service, in accordance with Article 230, and a storage battery of suitable rating and capacity to supply and maintain at not less than 91 per cent of system voltage the total load of the circuits supplying emergency lighting and emergency power for a period of not less than one and one-half hours.

Batteries whether of the acid or alkali type shall be designed and constructed to meet the requirements of emergency service. When of the lead-acid type, this shall include low gravity acid (1.20 to 1.22 SP-GR), relatively thick and rugged plates and separators, and a transparent jar.

700-8. Generator Set. One service, in accordance with Article 230, and a generator set driven by some form of prime mover and of sufficient capacity and proper rating to supply circuits carrying emergency lighting or lighting and power, with suitable means for automatically starting the prime mover on failure of the normal service. For hospitals, the transition time from instant of failure of the normal power source to the emergency generator source shall not exceed ten seconds.

See Section 700-4.

700-9. Separate Service. Two services, each in accordance with Article 230, widely separated electrically and physically to minimize possibility of simultaneous interruption of supply.

700-10. Connection Ahead of Service Disconnecting Means. Connections on the line side of the main service if sufficiently separated from main service to prevent simultaneous interruption of supply through an occurrence within the building or group of buildings served.

700-11. Auxiliary Source. The requirements of Section 700-5 and Section 700-6 shall also apply to installations where the entire electrical load on a service or sub-service is arranged to be supplied from a second source. Current supply from a standby power plant shall satisfy the requirements of availability in Section 700-6.

700-12. Derangement Signals. Audible and visual signal devices shall be provided where practicable for the following purposes:

(a) To give warning of derangement of the emergency or auxiliary source.
(b) To indicate that the battery or generator set is carrying load.
(c) To indicate when battery charger is properly functioning.

C. Emergency Circuits for Lighting and Power

700-13. Loads on Emergency Branch Circuits. No appliances and no lamps, other than those specified as required for emergency use shall be supplied by emergency lighting circuits.

700-14. Emergency Illumination. Emergency illumination shall include all required exit lights and all other lights specified as necessary to provide sufficient illumination.

Emergency lighting systems should be so designed and installed that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave any space in total darkness.

700-15. Circuits for Emergency Lighting. Branch circuits intended to supply emergency lighting shall be so installed as to provide service immediately when the normal supply for lighting is interrupted. Such installations shall provide either one of the following:

(a) An emergency lighting supply, independent of the general lighting system with provisions for automatically transferring, by means of devices approved for the purpose, the emergency lights upon the event of failure of the general lighting system supply.

(b) Two or more separate and complete systems with independent power supply, each system providing sufficient current for emergency lighting purposes. Unless both systems are used for regular lighting purposes and are both kept lighted, means shall be provided for automatically energizing either system upon failure of the other. Either or both systems may be part of the general lighting system of the protected occupancy if circuits supplying lights for emergency illumination are installed in accordance with other sections of this article.

700-16. Circuits for Emergency Power. For branch circuits which supply equipment classed as emergency, there shall be an emergency supply source to which the load will be transferred automatically and immediately upon the failure of the normal supply.

700-17. Independent Wiring. Emergency circuit wiring shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceway, box or cabinet with other wiring except:

Exception No. 1. In transfer switches.

Exception No. 2. In exit or emergency lighting fixtures supplied from two sources.

D. Control

700-18. Switch Requirements. The switch or switches installed in emergency lighting circuits shall be so arranged that only authorized persons will have control of emergency lighting except:

Exception No. 1. Where two or more single throw switches are connected in parallel to control a single circuit, at least one of these switches shall be accessible only to authorized persons.

Exception No. 2. Additional switches which act only to put emergency lights into operation but not disconnect them are permissible.

Switches connected in series or three and four way switches shall not be used.

700-19. Switch Location.

(a) All manual switches for controlling emergency circuits shall be in locations convenient to authorized persons responsible for their actuation. In places of assembly such as theaters a switch for controlling emergency lighting systems shall be located in the lobby or at a place conveniently accessible thereto.

(b) In no case shall a control switch for emergency lighting in a theater or motion-picture theater be placed in a motion-picture projection booth or on a stage, except that where multiple switches are provided, one such switch may be installed in such location when so arranged that it can energize, but not disconnect, the circuit.

700-20. Other Switches

(a) **Exterior Lights.** Those lights on the exterior of the building which are not required for illumination when there is sufficient daylight may be controlled by an automatic light-actuated device approved for the purpose.

(b) Hospital Corridors. Switching arrangements to transfer corridor lighting in patient areas of hospitals from overhead fixtures to fixtures designed to provide night lighting may be permitted, provided the switching system is so designed that switches can only select between two sets of fixtures and cannot extinguish both sets at the same time.

E. Overcurrent Protection

700-21. Accessibility. The branch-circuit overcurrent devices in emergency circuits shall be accessible to authorized persons only.

F. Unit Equipments

700-22. Unit Equipments. Where permitted by the authority having jurisdiction, in lieu of other methods specified elsewhere in this Article, individual unit equipments for emergency illumination shall consist of (a) a battery, (b) battery charging means when a storage battery is used, (c) one or more lamps, and (d) a relaying device arranged to energize the lamps automatically upon failure of the normal supply to the building.

> The batteries shall be of suitable rating and capacity to supply and maintain at not less than 91 per cent of rated lamp voltage the total lamp load associated with the unit for a period of not less than one and one-half hours.

Storage batteries whether of the acid or alkali type shall be designed and constructed to meet the requirements of emergency service. When of the lead-acid type the storage battery shall have a transparent jar.

Unit equipments shall be permanently fixed in place (i.e., not portable) and shall have all wiring to each unit installed in accordance with the requirements of any of the wiring methods in Chapter 3. They shall not be connected by flexible cord. The supply circuit between the unit equipment and the service, feeders, or the branch circuit wiring shall be installed as required by Section 700-17. Emergency illumination fixtures which obtain power from a unit equipment and are not part of the unit equipment shall be wired to the unit equipment as required by Section 700-17 and by one of the wiring methods of Chapter 3.

ARTICLE 710 — OVER 600 VOLTS — GENERAL

A. General

710-1. Scope. This Article applies in general to all circuits and equipment operated at more than 600 volts. For specific installation see the Articles referred to in Section 710-2.

710-2. Installations Covered in Other Articles. Provisions applicable to specific types of installations are included in Article 230, Services; Article 346, Rigid Metal Conduit; Article 347, Rigid Nonmetallic Conduit; Article 430, Motors, Motor Circuits and Controllers; Article 450, Transformers and Transformer Vaults; Article 460, Capacitors; Article 730, Outside Branch Circuits and Feeders; Article 410, Lighting Fixtures, Lampholders, Lamps, Receptacles and Rosettes; Article 600, Electric Signs and Outline Lighting; Article 660, X-ray Equipment, and Article 665, Inductive and Dielectric Heat Generating Equipment.

710-3. Wiring Methods. Circuit conductors shall be suitable for the voltage and the conditions under which they are installed. They shall be installed in rigid metal conduit, in raceways or ducts or as open runs of metal.armored cable suitable for the use and purpose.

When installed in the ground they shall be suitable for the purpose and buried at least 36 inches deep. Where this is impractical they may be not less than 24 inches deep provided they are installed in suitable raceways or encased in 2 inches of concrete. (See Articles 346 and 347.)

Exception. In locations accessible to qualified persons only, open runs of nonmetallic sheathed cable, bare conductors and bare bus-bars may also be used.

710-4. Braid-Covered Insulated Conductors — Open Installation. Open runs of braid-covered insulated conductors shall have a flame-retardant braid. When the conductors used do not have this protection, a flame-retardant saturant shall be applied to the braid covering after installation. This treated braid covering shall be stripped back a safe distance at conductor terminals, according to the operating voltage. This distance should be not less than one inch for each kilovolt of the conductor-to-ground voltage of the circuit, where practicable.

710-5. Shielding of Rubber Insulated Conductors. Where rubber-insulated conductors for permanent installations operate at voltages higher than those indicated in Table 710-5 and under the conditions mentioned, they shall be of a type having metallic shielding for the purpose of confining their dielectric field.

710-6. Grounding of Shielding Tape. The metallic shielding or any other static voltage shields on shielded cable shall be stripped back to a safe distance according to the circuit voltage, at all terminations of the shielding, as in potheads and joints. At such points, suitable methods such as the use of potheads, terminators, stress cones or similar devices shall be employed for stress reduction and the metallic shielding tape shall be grounded.

Table 710-5
Shielding of Rubber-Insulated Conductors

Method of Installation	Voltage in Kv (L-L) Above which Shielding is Required — Neutral Grounded: Fibrous Covered	Neutral Grounded: Ozone-Resistant Jacket Covering	Neutral Ungrounded: Fibrous Covered	Neutral Ungrounded: Ozone-Resistant Jacket Covering
In metallic conduit or trough above grade located indoors and in dry locations				
Single conductor ...	2	5*	2	3
Multi-conductor	2	5	2	5
Underground ducts and conduits and other wet locations				
Single conductor ...	2	3**	2	3
Multi-conductor	2	5	2	5
On insulators —				
Only multi-conductor	Not required under 5 Kv.		3	5
Directly in soil —				
Single conductor ...	—	3	—	3
Multi-conductor	—	5	—	5

*It is presumed that installation conditions will be such as to maintain a high level of jacket surface resistivity and so minimize the possibility of destructive discharge. Pulling dry or the use of insulating type pulling lubricants will help attain these conditions. Where surface contamination cannot be prevented and high surface resistivity cannot be maintained, metallic shielding shall be used at over 3 kv.

NOTE: Metallic sheathed single or 3 conductor cables require no metallic shielding for voltages 5 kv and less. In the case of portable equipment cables it is good practice to specify shielding for all voltages above 2 kv.

**For three single conductor cables, cabled together without overall outer covering, the value is 5 kv.

710-7. Grounding. Wiring and equipment installations shall conform with the applicable provisions of Article 250.

710-8. Moisture or Mechanical Protection for Metal Sheathed Cables. Where cable conductors emerge from a metal sheath and where protection against moisture or mechanical injury is necessary, the insulation of the conductors shall be protected by a pothead or other approved means.

B. Equipment — General Provisions

710-10. Indoor Installations. Indoor electrical equipment installations shall conform with Sections 710-10(a-c).

(a) In Public Places. In places which are regularly open to the public, electrical installations shall conform with Sections 710-31 to 710-34 inclusive. Metal-enclosed switch-gear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. Openings in ventilated dry-type transformers or similar openings in other equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(b) In Places Frequented Only By Persons Employed on the Premises. In places where access is normally restricted to persons employed on the premises, enclosure of electrical installations is not mandatory provided that: (1) No live parts are exposed or readily accessible; (2) The associated conduits or Type AC metal-clad cables terminate in, and are securely fastened to, the terminal chamber, casing or enclosure of the equipment; (3) Openings in ventilated dry-type transformers or similar openings in other equipment are designed so that foreign objects inserted through these openings will be deflected from energized parts.

(c) In Places Accessible to Qualified Persons Only. Electrical installations shall conform with Sections 710-31 to 710-34 inclusive.

710-11. Outdoor Installations. Outdoor installations having exposed live parts shall be accessible to qualified persons only. Installations are considered to be accessible to qualified persons only where enclosed as provided in Section 710-31 or when isolated by elevation. Live parts are deemed to be isolated by elevation (1) where the clearance to ground and to buildings conforms with Article 730 for outdoor installations, and (2) as provided in Section 710-34(f) for locations accessible to qualified persons only.

710-12. Metal Enclosed Equipments. Installations consisting of metal enclosed equipments such as metal clad switchgear, transformers, and the like, which have no exposed live parts, need not comply with Section 710-31. Ventilating or similar openings in equipment shall be so designed that foreign objects inserted through these openings will be deflected from energized parts. Where exposed to physical damage from vehicular traffic suitable guards shall be provided.

C. Equipment — Specific Provisions

See also references to specific types of installations in Section 710-2.

710-21. Circuit Interrupting Devices.

(a) Circuit Breakers.

(1) Indoor installations shall consist of metal-enclosed units or fire-resistant cell-mounted units except that open mounting of circuit breakers is permissible in locations accessible to qualified persons only.

(2) Circuit breakers shall be trip-free in all positions. In every installation the circuit breaker rating in respect to closing, carrying or interrupting capabilities shall not be less than the short circuit duty at the point of application.

(3) Circuit breakers used to control oil-filled transformers should be located outside the transformer vault.

(4) Circuit breakers shall have a means of indicating the open and closed position of the breaker at the point(s) from which they may be operated.

(5) Oil circuit breakers shall be so arranged or located that adjacent readily combustible structures or materials are safeguarded in an approved manner. Adequate space separation, fire-resistant barriers or enclosures, trenches containing sufficient coarse crushed stone and properly drained oil enclosures such as dikes or basins are recognized as suitable for this purpose.

(b) Fuseholders and Fuses.

(1) Fuses which expel flame in opening the circuit shall be so designed or arranged that they will function properly without hazard to persons or property.

(2) Fuseholders shall be designed so that they can be de-energized while replacing a fuse unless the fuse and fuseholder are designed to permit fuse replacement by qualified persons using equipment designed for the purpose without de-energizing the fuseholder.

(3) When high voltage fused cutouts are installed in a building or a transformer vault, they shall be of a type designed for use in buildings. Where such cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved switch or contactor shall be provided which is capable of interrupting the entire load. In addition, the cutouts shall be interlocked with the approved interrupter or bear a conspicuous sign reading "Do Not Open Cutout Under Load."

The cutouts shall be so located that they may be readily and safely operated and re-fused. Fuses shall be accessible from a clear floor space.

(c) Load Interrupters. Load interrupter switches may be used providing suitable fuses or circuit breakers are applied in conjunction with these devices to interrupt fault currents. When these devices are used in combination they shall be so coordinated electrically that they will safely withstand the effects of closing, carrying or interrupting all possible currents up to the assigned maximum short circuit rating.

710-22. Isolating Means. Means shall be provided to completely isolate an item of equipment. The use of isolating switches is not necessary where there are other ways of de-energizing the equipment for inspection and repairs such as metal-enclosed switchgear units, and removable truck panels. Isolating switches should be interlocked with the associated circuit interrupting device to prevent their being opened under load, otherwise signs warning against opening them under load shall be provided. Barriers should be provided on both sides of each pole of indoor open-type isolating switches. A fuseholder and fuse, designed for the purpose, may be used as an isolating switch.

D. Installations Accessible To Qualified Persons Only

710-31. Enclosure for Electrical Installations. Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen or fence, access to which is controlled by lock and key or other approved means, are considered to be accessible to qualified persons only. The height of the wall, screen or fence should not be less than eight feet over-all, unless designed to provide an equivalent degree of isolation. The type of enclosure used in a given case shall be designed and constructed according to the nature and degree of the hazard(s) associated with the installation. Article 450 covers minimum construction requirements for oil-filled transformer vaults.

Isolation by elevation is covered in Sections 710-11 and 710-34.

710-32. Circuit Conductors. They may be installed in conduit; in duct systems; as metal-armored cable; as bare wire, cable and buses, or as nonmetallic sheathed cables or conductors as provided in Sections 710-3 to 710-6 inclusive. Bare live conductors shall conform with Sections 710-33 and 710-34.

Insulators, together with their mounting and conductor attachments, when used as supports for wires, single conductor cables and bus-bars, shall be capable of safely withstanding the maximum magnetic forces which would prevail when two or more conductors of a circuit were subjected to short-circuit current.

Open runs of insulated wires and cables, having a bare lead sheath or a braided outer covering, shall be supported in a manner designed to prevent physical damage to the braid or sheath. Supports for lead covered cables shall be designed to prevent electrolysis of the sheath.

710-33. Minimum Space Separation Between Live Parts and Adjacent Surfaces. The minimum indoor air separation between bare live conductors and between such conductors and adjacent surfaces shall be not less than the values given below. This Section applies to interior wiring design and construction. It does not apply to the space separation provided in electrical apparatus and wiring devices.

Table 710-33. Minimum Air Separation in Inches, Indoors*

Circuit Voltage	Between Bare Live Conductors	Between Bare Live Conductors and Adjacent Surfaces
5,000	3.5	2.5
15,000	7	5.5
25,000	11	8.5

***The values given are the minimum permissible space separation under favorable service conditions. They should be increased under unfavorable service conditions or wherever space limitations permit. Proportional values may be used for intermediate voltages.**

710-34. Work Space and Guarding.

(a) Working Space. The minimum clear working space in front of electrical equipment, such as switchboards, control panels, switches, circuit breakers, motor controllers, relays and similar equipment shall not be less than set forth in the following table unless otherwise specified in this Code.

Table 710-34(a)
Minimum Clear Working Space in Front of Electrical Equipment

Voltage to Ground	Conditions		
	1	2	3
601–2500	3 ft.	4 ft.	5 ft.
2501–7500	4 ft.	5 ft.	6 ft.
over 7500	5 ft.	6 ft.	9 ft.

Where the "Conditions" are as follows:

(1) Exposed live parts on one side and no live or grounded parts on the other side of the working space or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not more than 300 volts shall not be considered live parts.

(2) Exposed live parts on one side and grounded parts on the other side. Concrete, brick or tile walls will be considered as grounded surfaces.

(3) Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

Exception: Working space is not required in back of assemblies such as dead-front switchboards or control assemblies when there are no renewable or adjustable parts such as fuses or switches on the back and when all connections are accessible from other locations than the back.

(b) Separation from Low-Potential Equipment. When switches, cutouts or other equipment operating at 600 volts or less are installed in a room or enclosure where there are exposed live parts or exposed wiring operating at more than 600 volts the high potential equipment shall be effectively separated from the space occupied by the low potential equipment by a suitable partition, fence, or screen.

Exception: Switches or other equipment operating at 600 volts or less and serving only equipment within the high-voltage vault, room or enclosure may be installed in the high-voltage enclosure, room or vault if accessible to qualified persons only.

(c) Locked Rooms or Enclosures. The entrances to all buildings, rooms or enclosures containing exposed live parts or exposed conductors operating in excess of 600 volts shall be kept locked, except where such entrances are at all times under the observation of a qualified attendant.

Where the voltage exceeds 600 volts permanent and conspicuous warning signs shall be provided, reading substantially as follows: "Warning — High Voltage — Keep Out."

(d) Illumination. Adequate illumination shall be provided for all working spaces about electrical equipment. The light outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment.

The points of control shall be so located that persons are not liable to come into contact with any live part or moving part of the equipment while turning on the lights.

(e) Headroom. The minimum headroom above working spaces about switching equipment where there are live parts exposed at any time shall be not less than 6½ feet.

(f) Elevation of Unguarded Live Parts. Unguarded live parts above working space shall be maintained at elevations not less than required by the following table.

Table 710-34(f)
Elevation of Unguarded Live Parts Above the Working Space

Voltage Between Phases	Minimum Vertical Clearance of Unguarded Parts Feet	Inches
601–6600	8	0
6601–11000	9	0
11001–22000	9	3
22001–33000	9	6
33001–44000	9	10
44001–66000	10	5
66001–88000	11	0
88001–110000	11	7
110001–132000	12	2

ARTICLE 720 — CIRCUITS AND EQUIPMENT OPERATING AT LESS THAN 50 VOLTS

720-1. General. This Article shall apply to installations operating at less than 50 volts, direct current or alternating current, except such as are treated in Articles 650 and 725.

720-2. Hazardous Locations. Circuits or equipment coming within the scope of this Article and installed in hazardous locations shall comply with the appropriate provisions of Articles 500-517 inclusive.

720-3. Larger Current at Lower Voltage. Conductors, devices, and equipment shall have current ratings sufficient for the greater current required to deliver equal power at the lower voltage than at usual voltages.

720-4. Conductors. Conductors shall be not smaller than No. 12, and for appliance branch circuits supplying more than one appliance or appliance receptacle, conductors shall be not smaller than No. 10. (See Section 300-1.)

720-5. Lampholders. Standard lampholders of rating not less than 660 watts shall be used.

720-6. Receptacle Rating. Receptacles shall have a rating not less than 15 amperes.

720-7. Receptacles Required. Receptacles of not less than 20-ampere rating shall be provided in kitchens, laundries, and other locations where portable appliances are likely to be used.

720-8. Overcurrent Protection. Overcurrent protection shall comply with the provisions of Article 240.

720-9. Batteries. See Article 480.

720-10. Grounding. See Sections 250-8 and 250-45(c).

ARTICLE 725 — REMOTE-CONTROL, LOW-ENERGY POWER, LOW-VOLTAGE POWER AND SIGNAL CIRCUITS

A. Scope and General

725-1. Scope. Provisions of this Article shall apply to remote-control circuits, including low voltage relay switching, low-energy power circuits, low-voltage power circuits and signal circuits, as defined in Article 100, Definitions.

The provisions of this Article are not intended to apply to remote-control, low-energy or signal circuits which form an integral part of a device or appliance.

725-2. Hazardous Locations. Circuits or equipment coming within the scope of this Article and installed in hazardous locations shall also comply with the appropriate provisions of Articles 500-517 inclusive.

725-3. Classification. Remote-control and signal circuits shall be classified as follows:

(a) Class 1 Circuits. Control and signal circuits in which power is not limited in accordance with Section 725-31.

(b) Class 2 Circuits. Control and signal circuits in which the power is limited in accordance with Section 725-31.

725-4. Low-Energy Power Circuits. Circuits which are neither remote-control nor signal circuits, but which have the power limited in accordance with Section 725-31 shall, for the purpose of this Code, be treated as Class 2 remote-control circuits.

725-5. Low-Voltage Power Circuits. Circuits which are neither remote-control nor signal circuits but which operate at not more than 30 volts, where the current is not limited in accordance with Section 725-31, and which are supplied from a source not exceeding 1000 volt-amperes shall for the purpose of this Code be treated as Class 1 remote-control circuits.

725-6. Safety-Control Devices. Remote-control circuits to safety-control devices, the failure of operation of which would introduce a direct fire or life hazard, shall be considered as Class 1 circuits.

Room thermostats, service hot-water temperature regulating devices, and similar controls used in conjunction with electrically controlled domestic heating equipment, are not considered to be safety-control devices.

725-7. Remote-Control and Signal Circuits in Communication Cables. Remote-control and signal circuits, which use conductors in the same cable with communication circuits, shall, for the purpose of this Article, be classified as communication circuits and meet the requirements of Article 800, of this Code.

B. Class 1 System

725-11. Wiring Method. Conductors and equipment of Class 1 remote-control and signal systems and low voltage power circuits shall be installed in accordance with the requirements of the appropriate Articles in Chapter 3 of this Code, except as provided in Sections 725-12 to 725-15 inclusive.

725-12. Other Articles. The wiring method required in Section 725-11 does not apply where other Articles of this Code specifically permit or require other methods for remote-control or signal circuits. See Article 620, Elevators, for example.

725-13. Conductor Sizes. Nos. 18 and 16 gage conductors may be used provided they are installed in a raceway or a cable approved for the purpose, or in flexible cords in accordance with the provisions of Article 400.

725-14. Conductor Insulation. Conductors larger than No. 16 shall be rubber-covered Type R, thermoplastic-covered Type T, or other approved type. Fixed conductors Nos. 18 and 16 gage shall have an insulation at least equal to that of Type TF thermoplastic-covered fixture wire. Conductors approved for the purpose having insulation of a thickness less than specified above or having other kinds of insulation may be used.

725-15. Number of Conductors in Raceways. The number of conductors of remote-control or signal circuits in a raceway may be determined according to Section 300-17 and Note 8 of Tables 310-12 through 310-15 need not be observed. Where there are four or more conductors in a raceway, some of which are remote-control, as permitted by Section 300-3, the provisions of Note 8 of Tables 310-12 through 310-15 shall apply, as determined by the number of power and lighting circuit conductors only.

725-16. Conductors of Different Systems. Conductors of two or more Class 1 remote-control and/or signal circuits may occupy the same enclosure or raceway without regard to whether the individual systems or circuits are alternating or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the enclosure or raceway. Conductors of remote-control, low-energy power and signal circuits, in which the current is limited as for Class 2 systems, shall be considered as Class 1 system conductors for the purpose of this requirement if insulated and installed in accordance with the provisions for Class 1 system conductors. Power supply conductors may occupy the same enclosure or raceway with Class 1 system conductors when supplying only equipment to which Class 1 system conductors are connected.

725-17. Mechanical Protection of Remote-Control Circuits. Where damage to a remote-control circuit would introduce a hazard as covered in Section 725-6, all conductors of such remote-control circuits shall be installed in conduit, electrical metallic tubing, Type MI cable or be otherwise suitably protected from physical damage.

725-18. Overcurrent Protection. Conductors shall be protected against overcurrent in accordance with the ampacities of Tables 310-12 through 310-15 except as follows:

Exception No. 1. Other Articles. Where other Articles of this Code specifically permit or require other overcurrent protection. See Sections 430-72 and 620-61.

Exception No. 2. Conductors of Nos. 18 and 16. Conductors of Nos. 18 and 16 shall be considered as protected by overcurrent devices of 20-ampere rating or setting.

Exception No. 3. Omission of Overcurrent Protection. In remote-control and signal circuits having main and branch circuits, the branch circuits need not be individually protected against overcurrent where the operating voltage does not exceed 30 volts.

725-19. Location of Overcurrent Protection. Overcurrent devices shall be located at the point where the conductor to be protected receives its supply unless the overcurrent device protecting the larger conductor also protects the smaller conductor in accordance with Tables 310-12 through 310-15.

725-20. Circuits Extending Beyond One Building. Class 1 circuits which extend aerially beyond one building shall also meet the requirements of Article 730.

725-21. Grounding. Class 1 remote-control and signal circuits and equipment shall be grounded in accordance with Article 250.

C. Limitation of Low-Voltage Power Circuit

725-22. Overcurrent Protection. Transformer devices supplying low-voltage power circuits shall be provided with overcurrent protection in the secondary circuit rated or set at not more than 250 per cent of the rated secondary current of the transformer. Such protection and mounting shall be approved for the purpose. Overcurrent protection required shall not be interchangeable with protection of a higher rating. The overcurrent protection may be an integral part of a transformer or other power supply device approved for the purpose.

725-23. Transformer Rating. Transformer devices supplying low-voltage power circuits shall be approved for the purpose and be restricted in their rated output to not exceeding 1000 volt-amperes and to not exceeding 30 volts. They shall be marked where plainly visible to show their rated output and the voltage to be applied to the circuit.

A transformer is considered as meeting the 1000 volt-ampere requirement where the approximate temperature limit is reached at 1000 volt-ampere load.

D. Class 2 System Voltage and Current Limits

725-31. Limits of Class 2 Systems. Class 2 remote-control and signal systems, depending on the voltage shall have the current limited as follows:

(a) Maximum 15 Volts: 5 Amperes. Circuits in which the open-circuit voltage does not exceed 15 volts and having overcurrent protection of not more than 5-amperes rating. Where the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

(b) 15 to 30 Volts: 3.2 Amperes. Circuits in which the open-circuit voltage exceeds 15 volts but does not exceed 30 volts and having overcurrent protection of not more than 3.2 amperes rating. Where the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

(c) 30 to 60 Volts: 1.6 Amperes. Circuits in which open-circuit voltage exceeds 30 volts but does not exceed 60 volts and having overcurrent protection of not more than 1.6 amperes rating. Where the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, the overcurrent protection may be omitted.

(d) 60 to 150 Volts: 1 Ampere. Circuits in which the open-circuit voltage exceeds 60 volts but does not exceed 150 volts, and having overcurrent protection of not more than 1-ampere rating, provided that such circuits are equipped with current-limiting means other than overcurrent protection which will limit the current as a result of a fault to not exceeding 1 ampere.

725-32. Overcurrent Protection and Mounting. Where current is limited in Class 2 systems by means of overcurrent protection, such protection and its mounting shall be approved for the purpose. Overcurrent protection required shall not be interchangeable with protection of a higher rating. The overcurrent protection may be an integral part of a transformer or other power supply device approved for the purpose.

725-33. Transformer Rating. Transformer devices supplying Class 2 systems shall be approved for the purpose and be restricted in their rated output to not exceeding 100 volt-amperes. Such devices shall not be paralleled or otherwise interconnected. They shall be marked where plainly visible to show the voltage to be applied to the circuit.

A transformer is considered as meeting the 100 volt-ampere requirement if the approximate temperature limit is reached at a 100-volt-ampere load.

725-34. Transformer Leads. The primary leads of transformers supplying Class 2 remote-control and signal circuits may be smaller than No. 14 but not smaller than No. 18, provided they are not over 12 inches long, have insulation at least equal to type RF-2 rubber-covered fixture wire, or approved equivalent.

E. Installation of Class 2 Remote-Control and Signal Circuits

725-41. On Supply Side of Overcurrent Protection, Transformers or Current-Limiting Devices. Conductors and equipment on supply side of overcurrent protection, transformers or current-limiting devices shall be installed in accordance with the appropriate requirements of Chapter 3 of this Code. Transformers or other devices supplied from electric light and power circuits shall be protected by an overcurrent device with a rating or setting not exceeding 20 amperes.

725-42. On Load Side of Overcurrent Protection, Transformer or Current-Limiting Devices. Conductors on load side of overcurrent protection, transformer or current-limiting devices shall be insulated and shall comply with the following:

(a) Separation from Other Conductors. Conductors shall be separated from conductors of electric light and power circuits as follows:

(1) Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in a raceway unless permanently separated from the conductors of the other system by a continuous and firmly fixed nonconductor, such as porcelain tubes or flexible tubing, additional to the insulation on the wire.

(2) In Raceways and Boxes. Conductors of Class 2 remote-control and signal circuits shall not be placed in any raceway, compartment, outlet box or similar fitting with conductors for either light and power circuits or Class 1 signal and control circuits, unless the conductors of the different systems are separated by a partition; provided that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where power supply conductors are introduced solely for supplying power to the remote-control or signal equipment to which the other conductors in the enclosure are connected. (See Section 725-16.)

(3) In Shafts. Conductors may be run in the same shaft with conductors for light and power where the conductors of the two systems are separated at least 2 inches, or where the conductors of either system are encased in noncombustible tubing. In hoistways conductors shall be installed in rigid conduit or electrical metallic tubing except as provided for in Section 620-21 Exception No. 1.

(b) Vertical Runs. Conductors in a vertical run in a shaft or partition shall have a fire resistant covering capable of preventing the carrying of fire from floor to floor except where conductors are encased in tubing or other outer covering of noncombustible material or are located in a fireproof shaft having fire stops at each floor.

Where 3 or more conductors are used, such conductors shall be grouped under a common braid or covering.

(c) Conductor Insulation. Conductor insulation shall comply with the following:

(1) 30 Volts or Less. The insulation shall be suitable for the particular application.

The kind of insulation for the conductors is not specified in further detail as reliance is placed on current limitation to stop dangerous currents.

(2) 30 to 150 Volts. Conductors of a cable shall be of solid or stranded copper not smaller than No. 22 AWG, and shall have thermoplastic insulation of not less than 0.012 inch nominal (0.010 inch minimum) thickness. The cable conductors shall have a thermoplastic jacket overall having a nominal thickness of not less than 0.035 inch (0.030 inch minimum). Where the number of conductors in a cable exceeds 4, the thickness of the thermoplastic jacket overall shall be increased so as to provide equivalent performance characteristics. Similarly, where the size of conductors in a cable exceeds No. 16 gage, the thickness of the conductor insulation shall be increased so as to provide equivalent performance characteristics.

Two-conductor assemblies of No. 16 gage or smaller, may be in flat parallel construction with 1/32 inch nominal integral-insulation jacket and an 0.047 inch minimum web. Approved low-energy circuit cable may be used.

Other insulation having equivalent performance characteristics may be acceptable.

Where single conductors are used they shall be not smaller than No. 18 AWG and shall be insulated in conformity with Section 725-14.

725-43. Circuits Extending Beyond One Building. Class 2 remote-control and signal circuits which extend beyond one building and are so run as to be subject to accidental contact with light or power conductors operating at a potential exceeding 300 volts, shall also meet the requirements of Sections 800-2, 800-11 and 800-12.

725-44. Grounding. Class 2 remote-control and signal circuits and equipment shall be grounded in accordance with Article 250.

ARTICLE 730 — OUTSIDE BRANCH CIRCUITS AND FEEDERS

730-1. Scope. This Article applies to electrical equipment and wiring for the supply of utilization equipment located on or attached to the outside of public and private buildings, or run between buildings, structures or poles on other premises served; but, shall not apply to equipment or wiring of an electric or communication utility used in the exercise of its function as a utility.

730-2. Application of Other Articles. Application of other Articles, including additional requirements to specific cases of equipment and conductors, are as follows:

Articles

200 — Polarity Identification.
210 — Branch Circuits.
215 — Feeders.
230 — Services.
250 — Grounding.
500 — Hazardous Locations, General.
510 — Hazardous Locations, Specific.
600 — Signs and Outline Lighting.
710 — Circuits and Equipment Operating at More than 600 Volts.
725 — Remote Control and Signal Circuits.
800 — Communication Circuits.
810 — Radio and Television Circuits.

730-3. Calculation of Load.

(a) Branch Circuits. The load on every outdoor branch circuit is to be determined by the applicable provisions of Article 220.

(b) Feeders. The load to be expected on every outdoor feeder is to be determined by the procedure specified in Article 220.

730-4. Conductor Covering. Where within 10 feet of any building or structure, open conductors supported on insulators shall be insulated or covered. Conductors in cables or raceways, except Type MI Cable, shall be of the rubber-covered type or thermoplastic type and in wet locations shall comply with Section 310-5. Conductors for festoon lighting shall be of the rubber-covered or thermoplastic type.

730-5. Size of Conductors. The ampacity of outdoor branch circuits and feeder conductors shall be according to the rating in Tables 310-12 through 310-15 in order to carry the loads determined under Section 730-3.

730-6. Minimum Size of Conductor.

(a) Overhead Spans. Overhead conductors shall not be smaller than No. 10 for spans up to 50 feet in length, and not smaller than No. 8 for longer spans.

(b) Festoon Lighting. Overhead conductors for festoon lighting shall not be smaller than No. 12 unless supported by messenger wires. (See Section 730-25.)

(c) Over 600 Volts. Overhead conductors operating at more than 600 volts shall not be smaller than No. 6 when open individual conductors nor smaller than No. 8 when in cable.

730-7. Lighting Equipment on a Pole.

(a) For the supply of lighting equipment installed on a single pole or structure, the branch circuits shall comply with the requirements of Article 210.

(b) For multiwire branch circuits, a common neutral may be employed for the branch circuits, provided not more than 8 ungrounded conductors are used. Such a common neutral shall have an ampacity of not less than the maximum load of all the ungrounded conductors connected to any phase or polarity.

730-8. Disconnection.

(a) For branch circuits as required in Article 210.

(b) For feeders as required in Article 215. (At each building supplied by a feeder see Section 230-76.)

730-9. Overcurrent Protection.

(a) For branch circuits as required in Article 210.

(b) For feeders as required in Article 215.

730-10. Wiring on Buildings. Outside wiring on surfaces of buildings may be installed, for circuits of 600 volts or less, as open conductors on insulating supports, as multiple-conductor cable approved for the purpose, as aluminum sheathed cable, in rigid metal conduit, in busways as provided in Article 364, or in electrical metallic tubing. Circuits of more than 600 volts shall be installed as provided for services in Section 230-101. Circuits for sign and outline lighting shall be installed as provided in Article 600.

730-11. Circuit Exits and Entrances. Where outside branch and feeder circuits exit from or enter into buildings the installation shall comply with those requirements of Article 230 which apply to service entrance conductors.

730-12. Open Conductor Supports. Open conductors shall be supported on glass or porcelain knobs, racks, brackets, or strain insulators, approved for the purpose.

730-13. Festoon Supports. In spans exceeding 40 feet the conductors shall be supported by a messenger wire supported by approved strain insulators. Conductors or messenger wires shall not be attached to any fire escape, downspout, or plumbing equipment.

730-14. Open Conductor Spacings. Conductors shall conform to the following spacings:

(a) Open Conductors Exposed to the Weather. As provided in Section 230-47.

(b) Open Conductors Not Exposed to Weather. As provided in Section 230-48.

(c) Over 600 Volts. As provided in Section 230-101(c).

(d) Separation from Other Circuits. Open conductors shall be separated from open conductors of other circuits or systems by not less than 4 inches.

(e) Conductors On Poles. Conductors on poles shall have a separation of not less than 1 foot except when placed on racks or brackets. Conductors supported on poles shall provide a horizontal climbing space not less than the following:

Power conductors, below communication conductors	30 inches
Power conductors alone or above communication conductors:	
Less than 300 volts	24 inches
Exceeding 300 volts	30 inches
Communication conductors below power conductors	same as power conductors
Communication conductors alone or above power conductors	no requirement

730-15. Supports Over Buildings. See Section 230-25.

730-16. Point of Attachment to Buildings. See Section 230-26.

730-17. Means of Attachment to Buildings. See Section 230-27.

730-18. Clearance from Ground. Open conductors of not over 600 volts shall conform to the following:

(a) Over Driveways. Conductors above alleys and above driveways on other than residential property shall have a clearance above ground of not less than 18 feet.

(b) Over Lots. Conductors supplying lights in automobile parking lots, drive-in establishments, and similar commercial areas shall have clearances above ground of not less than 12 feet.

(c) Over Footwalks, etc. On residential property, and elsewhere across spaces accessible to pedestrians only, conductors between buildings shall have a clearance of not less than 10 feet.

Note: For clearances of conductors of over 600 volts see National Electrical Safety Code.

730-19. Clearances from Buildings for Conductors not in Excess of 600 Volts.

(a) Over Roofs. Open conductors shall not be less than 8 feet from the highest point of roofs. Conductors attached to roof structures shall be substantially supported. Wherever practicable, conductors crossing over buildings shall be supported on structures which are independent of the building.

For Service Drop Conductors see Section 230-24(a).

(b) Horizontal Clearances. Open conductors not attached to a building shall have a minimum horizontal clearance of 36 inches.

(c) Final Spans. Final spans of feeders or branch circuits to buildings which they supply or from which they are fed may be attached to the building but they shall be kept 3 feet from windows, doors, porches, fire escapes or similar locations.

(d) Zone for Fire Ladders. Where buildings exceed 3 stories, or 50 feet in height, overhead lines shall be arranged where practicable so that a clear space (or zone) at least 6 feet wide will be left either adjacent to the buildings or beginning not over 8 feet from them, to facilitate the raising of ladders when necessary for fire fighting.

Note: For clearance of conductors over 600 volts, consult National Electrical Safety Code.

730-20. Mechanical Protection of Conductors. Mechanical protection of conductors on buildings, structures or poles shall be as provided for services, Section 230-46.

730-21. Conductors Entering Buildings. Conductors entering buildings shall be as provided for services, Sections 230-44, -49, and -51.

730-22. Multiple Conductor Cables on Exterior Surfaces of Buildings. Multiple conductor cables on exterior surfaces of buildings shall be as provided for service cable, Section 230-50.

730-23. Raceways on Exterior Surfaces of Buildings. Raceways on exterior surfaces of buildings shall be made raintight and suitably drained.

730-24. Underground Circuits. Underground circuits shall be as provided for services, Sections 230-32 to -34.

730-25. Outdoor Lighting Equipment — Lampholders. Lampholders shall be of molded composition, or other approved material of the weatherproof type, and where they are attached as pendants shall have the connections to the circuit wires staggered. Where lampholders have terminals of a type which puncture the insulation and make contact with the conductors, they shall be attached only to conductors of the stranded type.

730-26. Outdoor Lighting Equipment — Location of Lamps. Location of lamps for outdoor lighting shall be below all live conductors, transformers, or other electrical equipment, unless clearances or other safeguards are provided for relamping operations, or unless the installation is controlled by a disconnecting means which can be locked in the open position.

Chapter 8. Communication Systems

ARTICLE 800 — COMMUNICATION CIRCUITS

A. General

800-1. Scope. The provisions of this Article shall apply to telephone, telegraph (except radio), district messenger, fire and burglar alarms and similar central station systems and to telephone systems not connected to a central station system but using similar type of equipment, methods of installation and maintenance.

Such protective measures as are essential to safeguard these systems under the various conditions to which they are subjected are outlined in these rules.

For detailed service requirements for fire alarm, sprinkler supervisory or watchman systems, see the Standards of the National Fire Protection Association.*

B. Protection

800-2. Protective Devices. A protector approved for the purpose shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be liable to accidental contact with light or power conductors operating at a potential exceeding 300 volts, and on each circuit run partly or entirely in aerial wire or cable not confined within a block.

The word "block" as used in this Article shall be construed to mean a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed but not any street.

(a) Location. The protector shall be located in or on the building as near as practicable to the point where the conductors enter. In the case of an underground entrance the protector may be located at the junction of the underground and the aerial wires.

(b) Hazardous Locations. The protector shall not be located in any hazardous location as defined in Article 500, nor in the vicinity of easily ignitible material.

(c) Protector Requirements. The protector shall be mounted on a noncombustible, nonabsorptive insulating base and shall consist of an arrester between each line conductor and the ground, and a fuse in each line conductor, the fuses protecting the arrester except as specified in Section 800-2(d). The protector terminals shall be plainly marked to indicate line, instrument, and ground.

(d) Omission of Fuses. A protector without fuses may be used under any of the following conditions:

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*The NFPA standards on fire alarm and supervisory systems are published by the NFPA in the National Fire Codes, Vol. 7 and in separate pamphlet form by the NFPA (NFPA Nos. 71, 72A, 72B, 72C, 72D, and 73).

(1) Where circuits enter a building through metal-sheathed cable, or through a nonmetallic sheathed cable having a metal grounding shield between the sheath and the conductor assembly, provided the metal sheath or shield of the cable is effectively grounded and the conductors in the cable shall safely fuse at currents less than the ampacity of the protector, the associated insulated conductors, and the protector grounding conductor.

(2) Where insulated conductors in accordance with Section 800-11 (c-1 and -2) are used to extend circuits to a building from a metal-sheathed cable or from a nonmetallic-sheathed cable having a metal grounding shield between the sheath and the conductor assembly provided the metal sheath or shield is effectively grounded and the conductors in the cable or cable stub shall safely fuse at currents less than the ampacity of the protector, the associated insulated conductors, and the protector grounding conductor.

(3) Where insulated conductors, in accordance with Section 800-11 (c-1) or (c) (2) are used to extend circuits to a building from other than grounded metal-sheathed or shielded cable, provided (a) the protector is approved for this purpose and (b) the protector grounding conductor is connected to a water pipe electrode or the grounding conductor or grounding electrode of a multi-grounded neutral power system and (c) the connections of the insulated conductors to the exposed plant or the conductors of the exposed plant shall safely fuse at currents less than the ampacity of the protector, the associated insulated conductors, and the protector grounding conductor.

(4) Where insulated conductors in accordance with Section 800-11(c-1 and -2) are used to extend circuits aerially to a building from an unexposed buried or underground circuit.

Effectively grounded means permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity to prevent the building up of voltages which may result in undue hazard to connected equipment or to persons.

800-3. Installation of Conductors. Conductors from the protector to the equipment or, where no protector is required, conductors attached to the outside of, or inside the building shall comply with the following:

(a) Separation from Other Conductors. Conductors shall be separated from conductors of electric light and power circuits as follows:

(1) Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in metallic raceways or metal-sheathed cable unless permanently separated from the conductors of the other system by a continuous and firmly fixed nonconductor, additional to the insulation on the wire, such as porcelain tubes or flexible tubing.

(2) In Raceways and Boxes. Communication conductors shall not be placed in any raceway, compartment, outlet box, junction box or similar fitting with conductors for light and power circuits or Class 1 signal and control circuits unless the conductors of the different systems are separated by a partition; provided that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where such conductors are introduced solely for power supply to communication equipment or for connection to remote-control equipment.

(3) In Shafts. Conductors may be run in the same shaft with conductors for light and power provided the conductors of the two systems are separated at least 2 inches, or where the conductors of either system are encased in noncombustible tubing.

(b) Vertical Runs. Conductors bunched together in a vertical run in a shaft shall have a fire-resistant covering capable of preventing the carrying of fire from floor to floor, except where conductors are encased in noncombustible tubing or are located in a fireproof shaft having fire stops at each floor.

The conductors referred to in this Section would ordinarily be insulated but the kind of insulation is not specified as reliance is placed on the protective device to stop all dangerous voltages and currents.

C. Outside Conductors

800-11. Overhead Conductors. Overhead conductors entering buildings shall comply with the following:

(a) On Poles. Where communication conductors and light or power conductors are supported by the same pole, the following conditions shall be met:

(1) Relative Location. The conductors should preferably be located below the light or power conductors.

(2) Attachment to Crossarms. Conductors shall not be attached to a crossarm which carries light or power conductors.

(3) Climbing Space. The climbing space through signal conductors shall comply with the requirements of Section 730-14.

(b) On Roofs. Conductors passing over buildings shall be kept at least 8 feet above any roof which may be readily walked upon, except small auxiliary buildings such as garages and the like.

(c) Circuits Requiring Protectors. Circuits which require protectors (see Section 800-2) shall comply with the following:

(1) Insulation, Single or Paired Conductors. Each conductor, from the last outdoor support to the protector, shall have 1/32-inch rubber insulation, except that when such conductors are entirely within a block the insulation on the conductor may be less than 1/32 inch, but not less than 1/40 inch in thickness. In addition, the conductor, either individually or over the pair, shall be covered with a substantial fibrous covering or equivalent protection. Conductors approved for the purpose having rubber insulation of a thickness less than specified above, or having other kinds of insulation may be used.

(2) Insulation, Cables. Conductors within a cable of the metal-sheathed type, or within a cable having a rubber sheath of at least 1/32-inch thickness and covered with a substantial fibrous covering, may have paper or other suitable insulation. Where the metal or rubber sheath is omitted, each conductor shall be insulated as required in Section 800-11(c-1), and the bunched conductors shall be covered with a substantial fibrous covering or equivalent covering.

(3) On Buildings. Open conductors shall be separated at least 4 inches from light or power conductors not in conduit or cable, unless permanently separated from conductors of the other system by a continuous and firmly fixed nonconductor additional to the insulation on the wires, such as porcelain tubes or flexible tubing. Open conductors exposed to accidental contact with light and power conductors operating at over 300 volts, and attached to buildings, shall be separated from woodwork by being supported on glass, porcelain or other insulating material approved for the purpose except that such separation is not required where fuses are omitted as provided for in Section 800-2(d) or where conductors approved for the purpose are used to extend circuits to a building from a cable having a grounded metal sheath.

(4) Entering Buildings. Where a protector is installed inside the building, the conductors shall enter the building either through a noncombustible, nonabsorptive insulating bushing, or through a metal raceway. The insulating bushing may be omitted where the entering conductors (1) are in metal-sheathed cable, (2) pass through masonry, (3) are approved for the purpose and fuses are omitted as provided for in Section 800-2(d), or (4) are approved for the purpose and are used to extend circuits to a building from a cable having a grounded metal sheath. Raceways or bushings shall slope upward from the outside or, where this cannot be done, drip loops shall be formed in the conductors immediately before they enter the building. Raceways shall be equipped with an approved service head. More than one conductor may enter through a single raceway or bushing. Conduits or other metallic raceways located ahead of the protector shall be grounded.

800-12. Lightning Conductors. Where practicable, a separation of at least six feet shall be maintained between open conductors of communication systems on buildings and lightning conductors.

D. Underground Circuits

800-21. Underground Circuits. Underground conductors of communication circuits entering buildings shall comply with the following:

(a) With Electric Light or Power Conductors. Underground conductors in a duct, handhole, or manhole containing electric light or power conductors, shall be in a section separated from such conductors by means of brick, concrete, or tile partitions.

(b) Underground Block Distribution. Where the entire street circuit is run underground and the circuit within the block is so placed as to be free from liability of accidental contact with electric light or power circuits of over 300 volts, the insulation requirements of Section 800-11 (c-1 and c-4) shall not apply, the conductors need not be placed on insulating supports and no bushings shall be required where the conductors enter the building.

E. Grounding

800-31. Grounding. Equipment shall be grounded as follows:

(a) Cable Sheath. The metal sheath of aerial cables entering buildings which are liable to contact with electric light or power conductors shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device.

(b) Protector Ground. The protector ground shall comply with the following:

(1) Insulation. The grounding conductor shall have a 1/32-inch rubber insulation and shall be covered by a substantial fibrous covering. Conductors approved for the purpose having less than 1/32-inch rubber insulation or having other kinds of insulation may be used.

(2) Size. The grounding conductor shall not be smaller than No. 18 copper.

(3) Run in Straight Line. The grounding conductor shall be run in as straight a line as practicable to the grounding electrode.

(4) Physical Damage. Where necessary, the grounding conductor shall be guarded from physical damage.

(5) Electrode. The grounding conductor shall preferably be connected to a water pipe electrode. Where a water pipe is not readily available and the grounded conductor of the power service is connected to the water pipe at the building, the protector grounding conductor may be connected to the power service conduit, service equipment enclosures, or grounding conductor of the power service.

Gas piping shall not be used for grounding. In the absence of a water pipe, connection may be made to an effectively grounded metallic structure, or to a ground rod or pipe driven into permanently damp earth. Steam or hot water pipes, or lightning rod conductors shall not be employed as electrodes for protectors. A driven rod or pipe used for grounding power circuits shall not be used for grounding communication circuits unless the driven rod or pipe is connected to the grounded conductor of a multigrounded neutral power system. The requirements for separate made electrodes for power and lighting system grounds, those for communication systems, and those for a lightning rod installation shall not prohibit the bonding together of all such made electrodes. See Section 250-86.

All separate electrodes shall be bonded together to limit potential differences between them and between their associated wiring systems.

(6) Electrode Connection. The grounding conductor shall be attached to a pipe electrode by means of a bolted clamp to which the conductor is soldered or otherwise connected in an effective manner.

In every case the connection to the grounding electrode shall be made as close to the earth as practicable.

ARTICLE 810 — RADIO AND TELEVISION EQUIPMENT

A. General

810-1. Scope. This Article shall apply to radio and television receiving equipment and to amateur radio transmitting and receiving equipment, but shall not apply to equipment and antennas used for coupling carrier current to power line conductors.

The authority enforcing this Code shall be freely consulted as to the specific methods to be followed in any case of doubt relative to installation of antenna conductors and that the National Electrical Safety Code, Part 5, be followed.

810-2. Application of Other Articles. Wiring from the source of power to and between devices connected to the interior wiring system shall comply with Chapters 1 to 4, inclusive, except as modified by Sections 640-3, 640-4 and 640-5. Wiring for radio-frequency and audio-frequency equipment and loudspeakers shall comply with Article 640.

810-3. Community Television Antenna. The antenna shall comply with the requirements of this Article. The distribution system shall comply with Article 800.

810-4. Radio Noise Suppressors. Radio interference eliminators, interference capacitors or radio noise suppressors connected to power supply leads shall be of a type approved for the purpose. They shall not be exposed to physical damage.

B. Receiving Equipment Only

Antenna Systems — General

810-11. Material. Antenna and lead-in conductors shall be of hard-drawn copper, bronze, aluminum alloy, copper-clad steel or other high-strength, corrosion-resistant material. Soft-drawn or medium-drawn copper may be used for lead-in conductors where the maximum span between points of support is less than 35 feet.

810-12. Supports. Outdoor antenna and lead-in conductors shall be securely supported. They shall not be attached to poles or similar structures carrying electric light or power wires or trolley wires of more than 250 volts between conductors. Insulators supporting the antenna conductors shall have sufficient mechanical strength to safely support the conductors. Lead-in conductors shall be securely attached to the antenna.

810-13. Avoidance of Contacts with Conductors of Other Systems. Outdoor antenna and lead-in conductors from an antenna to a building shall not cross over electric light or power circuits and shall be kept well away from all such circuits so as to avoid the possibility of accidental contact. Where proximity to electric light and power service conductors of less than 250 volts between conductors cannot be avoided, the installation shall be such as to provide a clearance of at least two feet. Antenna conductors shall be so installed as not to cross under electric light or power conductors.

810-14. Splices. Splices and joints in antenna spans shall be made with approved splicing devices or by such other means as will not appreciably weaken the conductors.

810-15. Grounding. Masts and metal structures supporting antennas shall be permanently and effectively grounded, without intervening splice or connection.

Antenna Systems — Receiving Station

810-16. Size of Wire-Strung Antenna.

(a) Outdoor antenna conductors for receiving stations shall be of a size not less than given in Table 810-16(a).

Table 810-16(a)
Size of Receiving-Station Outdoor Antenna Conductors

Material	Minimum Size of Conductors		
	When Maximum Open Span Length is		
	Less than 35 feet	35 feet to 150 feet	Over 150 feet
Aluminum alloy, hard-drawn copper	19	14	12
Copper-clad steel, bronze or other high strength material	20	17	14

For very long span lengths larger conductors will be required, depending on the length of the span and the ice and wind loading.

(b) **Self-Supporting Antennas.** Outdoor antennas, such as vertical rods or dipole structures, shall be of noncorrodible materials and of strength suitable to withstand ice and wind loading conditions, and shall be located well away from overhead conductors of electric light and power circuits of over 150 volts to ground so as to avoid the possibility of the antenna or structure falling into or accidental contact with such circuits.

810-17. Size of Lead-In. Lead-in conductors from outside antenna for receiving stations, shall, for various maximum open span lengths, be of such size as to have a tensile strength at least as great as that of the conductors for antenna as specified in Section 810-16. Where the lead-in consists of two or more conductors which are twisted together or are enclosed in the same covering or are concentric, the conductor size shall, for various maximum open span lengths, be such that the tensile strength of the combination will be at least as great as that of the conductors for antenna as specified in Section 810-16.

810-18. Clearances.

(a) On Buildings Outside. Lead-in conductors attached to buildings shall be so installed that they cannot swing closer than two feet to the conductors of circuits of 250 volts or less between conductors, or ten feet to the conductors of circuits of more than 250 volts between conductors, except that in the case of circuits not exceeding 150 volts between conductors, where all conductors involved are supported so as to insure permanent separation, the clearance may be reduced but shall not be less than four inches. The clearance between lead-in conductors and any conductor forming a part of a lightning rod system shall be not less than six feet unless the bonding referred to in Section 250-86 is accomplished.

(b) Antennas and Lead-Ins — Indoors. Indoor antennas and indoor lead-ins shall not be run nearer than two inches to conductors of other wiring systems in the premises unless

(1) such other conductors are in metal raceways or cable armor, or

(2) unless permanently separated from such other conductors by a continuous and firmly fixed nonconductor such as porcelain tubes or flexible tubing.

810-19. Electric Supply Circuits Used in Lieu of Antenna. Where an electric supply circuit is used in lieu of an antenna, the device by which the radio receiving set is connected to the supply circuit shall be specially approved for the purpose.

Lightning Arresters

810-20. Lightning Arresters — Receiving Stations. Each conductor of a lead-in from an outdoor antenna shall be provided with a lightning arrester approved for the purpose, except that where the lead-in conductors are enclosed in a continuous metallic shield the lightning arrester may be installed to protect the shield or may be omitted where the shield is permanently and effectively grounded. Lightning arresters shall be located outside the building, or inside the building between the point of entrance of the lead-in and the radio set or transformers, and as near as practicable to the entrance of the conductors to the building. The lightning arrester shall not be located near combustible material nor in a hazardous location as defined in Article 500.

Grounding Conductors — General

810-21. Material. The grounding conductor shall, unless otherwise specified, be of copper, aluminum, copper-clad steel, bronze, or other corrosion-resistant material.

810-22. Insulation. The grounding conductors may be uninsulated.

810-23. Supports. The grounding conductors shall be securely fastened in place and may be directly attached to the surface wired over without the use of insulating supports. Where proper support cannot be provided the size of the grounding conductor shall be increased proportionately.

810-24. Mechanical Protection. The grounding conductor shall be protected where exposed to physical damage or the size of the grounding conductor shall be increased proportionately to compensate for the lack of protection.

810-25. Run in Straight Line. The grounding conductor shall be run in as straight a line as practicable from the antenna mast and/or lightning arrester to the grounding electrode.

810-26. Grounding Electrode. The grounding conductor shall be connected to a metallic underground water piping system as specified in Section 250-81. Where the building is not supplied with a water system the connection shall be made to the metal frame of the building when effectively grounded or to a grounding electrode as specified in Section 250-83. At a penthouse or similar location the ground conductor may be connected to a water pipe or rigid conduit.

Grounding Conductors — Receiving Stations

810-27. Inside or Outside Building. The grounding conductor may be run either inside or outside the building.

810-28. Size. The grounding conductor shall be not smaller than No. 10 copper or No. 8 aluminum or No. 17 copper-clad steel or bronze.

810-29. Common Ground. A single grounding conductor may be used for both protective and operating purposes.

Where a single conductor is so used, the ground terminal of the equipment should be connected to the ground terminal of the protective device.

C. Amateur Transmitting and Receiving Stations

Antenna System

810-51. Other Sections. In addition to conforming to the requirements of Part C, antenna systems for amateur transmitting and receiving stations shall also comply with Sections 810-11 to 810-15 inclusive.

810-52. Size of Antenna. Antenna conductors for amateur transmitting and receiving stations shall be of a size not less than given in Table 810-52.

Table 810-52

Size of Amateur-Station Outdoor Antenna Conductors

Material	Minimum Size of Conductors	
	When Maximum Open Span Length Is	
	Less than 150 feet	Over 150 feet
Hard-drawn copper	14	10
Copper-clad steel, bronze or other high strength material	14	12

For very long span length larger conductors will be required, depending on the span length and the ice and wind loadings.

810-53. Size of Lead-In Conductors. Lead-in conductors for transmitting stations shall, for various maximum span lengths, be of a size at least as great as that of conductors for antenna as specified in Section 810-52.

810-54. Clearance on Building. Antenna conductors for transmitting stations, attached to buildings, shall be firmly mounted at least 3 inches clear of the surface of the building on nonabsorptive insulating supports, such as treated pins or brackets, equipped with insulators having not less than 3-inch creepage and airgap distances. Lead-in conductors attached to buildings shall also conform to these requirements, except when they are enclosed in a continuous metallic shield which is permanently and effectively grounded. In this latter case the metallic shield may also be used as a conductor.

810-55. Entrance to Building. Except where protected with a continuous metallic shield which is permanently and effectively grounded, lead-in conductors for transmitting stations shall enter buildings by one of the following methods:

(a) Through a rigid, noncombustible, nonabsorptive insulating tube or bushing.

(b) Through an opening provided for the purpose in which the entrance conductors are firmly secured so as to provide a clearance of at least 2 inches.

(c) Through a drilled window pane.

810-56. Protection Against Accidental Contact. Lead-in conductors to radio transmitters shall be so located or installed as to make accidental contact with them difficult.

810-57. Lightning Arresters — Transmitting Stations. Each conductor of a lead-in for outdoor antenna shall be provided with a lightning arrester or other suitable means which will drain static charges from the antenna system.

Exception No. 1. Where protected by a continuous metallic shield which is permanently and effectively grounded.

Exception No. 2. Where the antenna is permanently and effectively grounded.

Grounding Conductors — General

810-58. Other Sections. All grounding conductors for amateur transmitting and receiving stations shall comply with Sections 810-21 to 810-27 inclusive.

810-59. Size of Protective Ground. The protective ground conductor for transmitting stations shall be as large as the lead-in, but not smaller than No. 10 copper, bronze, or copper-clad steel.

810-60. Size of Operating Grounding Conductor. The operating grounding conductor for transmitting stations shall be not less than No. 14 copper or its equivalent.

Interior Installation — Transmitting Stations

810-70. Clearance From Other Conductors. Except as provided in Article 640, all conductors inside the building shall be separated at least 4 inches from the conductors of any other light or signal circuit unless separated therefrom by conduit or some firmly fixed nonconductor such as porcelain tubes or flexible tubing.

810-71. General. Transmitters shall comply with the following:

(a) Enclosing. The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

(b) Grounding of Controls. All external metallic handles and controls accessible to the operating personnel shall be effectually grounded.

No circuit in excess of 150 volts between conductors should have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

(c) Interlocks on Doors. All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts between conductors when any access door is opened.

(d) Audio-Amplifiers. Audio-amplifiers which are located outside the transmitter housing shall be suitably housed and shall be so located as to be readily accessible and adequately ventilated.

Chapter 9 — Tables and Examples

A. Tables

Where conduit nipples having a maximum length not to exceed six inches are installed between boxes, cabinets, gutters, switch cases and similar enclosures, the conductor fill in such nipples may be increased to not more than 60 per cent of the internal cross-sectional area of the conduit, and note 8 of Tables 310-12 through 310-15 does not apply to this condition.

Tables 1, 2 and 3 apply only to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from physical damage.

Table 1. Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

New Work or Rewiring — Types RF-2, RFH-2, R, RH, RW, RHH, RHW, RH-RW

New Work — FEP, FEPB, RUH, RUW, T, TF, THHN, THW, THWN, TW

Derating factors for more than three conductors in raceways, see Note 8, Tables 310–12 through 310–15.

(See Section 300–17, 300–18, 346–6 and 348–6)

New Work or Rewiring

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % conductor fill, Table 3, Chap. 9, for new work)											
	½ Inch	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch
18	7	12	20	35	49	80	115	176				
16	6	10	17	30	41	68	98	150				
14	4	6	10	18	25	41	58	90	121	155		
12	3	5	8	15	21	34	50	76	103	132	208	
10	1	4	7	13	17	29	41	64	86	110	173	
8	1	3	4	7	10	17	25	38	52	67	105	152
6	1	1	3	4	6	10	15	23	32	41	64	93
4	1	1	1	3*	5	8	12	18	24	31	49	72
3		1	1	3	4	7	10	16	21	28	44	63
2		1	1	3	3	6	9	14	19	24	38	55
1		1	1	1	3	4	7	10	14	18	29	42
0			1	1	2	4	6	9	12	16	25	37
00			1	1	1	3	5	8	11	14	22	32
000			1	1	1	3	4	7	9	12	19	27
0000				1	1	2	3	6	8	10	16	23
250				1	1	1	3	5	6	8	13	19
300				1	1	1	3	4	5	7	11	16
350				1	1	1	1	3	5	6	10	15
400					1	1	1	3	4	6	9	13
500					1	1	1	3	4	5	8	11
600						1	1	1	3	4	6	9
700						1	1	1	3	3	6	8
750						1	1	1	3	3	5	8
800						1	1	1	2	3	5	7
900						1	1	1	1	3	4	7
1000						1	1	1	1	3	4	6
1250							1	1	1	1	3	5
1500								1	1	1	3	4
1750								1	1	1	2	4
2000								1	1	1	1	3

* Where an existing service run of conduit or electrical metallic tubing does not exceed 50 ft. in length and does not contain more than the equivalent of two quarter bends from end to end, two No. 4 insulated and one No. 4 bare conductors may be installed in 1-inch conduit or tubing.

Table 1A.

Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

Rewiring — Types TF, T, THW, TW, RUH, RUW

Derating Factors for more than three conductors in raceways

See Note 8, Tables 310–12 through 310–15

(See Section 300–17, 300–18, 346–6 and 348–6)

Rewiring

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % Conductor-fill, Table 3, Chapter 9, for new work)											
	½ Inch	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch
18	13	24	38	68	93	152	–	–	–	–	–	–
16	11	19	31	55	75	123	176	270	–	–	–	–
14	5	10	16	29	40	65	93	143	192	–	–	–
12	4	8	13	24	32	53	76	117	157	202	–	–
10	4	6	11	19	26	43	61	95	127	163	257	–
8	1	4	6	11	15	25	36	56	75	96	152	219
6	1	2	4	7	10	16	23	36	48	62	97	141
4	1	1	3	5	7	12	17	27	36	46	73	106
3	1	1	2	4	6	10	15	23	31	40	63	91
2	1	1	1	4	5	9	13	20	27	34	54	78
1	–	1	1	2	4	6	9	14	19	25	39	57
0	–	1	1	2	3	5	8	12	16	21	33	48
00	–	1	1	1	3	4	7	10	14	18	28	41
000	–	–	1	1	2	4	5	9	12	15	24	35
0000	–	–	1	1	1	3	5	7	10	13	20	29
250	–	–	–	1	1	2	4	6	8	10	16	23
300	–	–	–	1	1	2	3	5	7	9	14	20
350	–	–	–	1	1	1	3	4	6	8	12	18
400	–	–	–	1	1	1	2	4	5	7	11	16
500	–	–	–	–	1	1	1	3	4	6	9	14
600	–	–	–	–	1	1	1	3	4	5	7	11
700	–	–	–	–	–	1	1	2	3	4	7	10
750	–	–	–	–	–	1	1	2	3	4	6	9
800	–	–	–	–	–	1	1	1	3	4	6	9
900	–	–	–	–	–	1	1	1	2	3	5	8
1000	–	–	–	–	–	1	1	1	2	3	5	7
1250	–	–	–	–	–	–	1	1	1	2	4	6
1500	–	–	–	–	–	–	1	1	1	1	3	5
1750	–	–	–	–	–	–	1	1	1	1	3	4
2000	–	–	–	–	–	–	–	1	1	1	2	4

Table 1B.

Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

Rewiring — Types FEP, FEPB, THHN, THWN

See Tentative Interim Amendment No. 133 at back of book.

Derating Factors for more than three conductors in raceways

See Note 8, Tables 310–12 through 310–15

(See Section 300–17, 300–18, 346–6 and 348–6)

Rewiring

Size AWG or MCM	Maximum Number of Conductors in Conduit or Tubing (Based upon % Conductor-fill, Table 3, Chapter 9, for new work)											
	½ Inch	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch
14	13	24	39	69	94	154	220	–	–	–	–	–
12	10	18	29	51	70	114	164	252	–	–	–	–
10	6	11	18	32	44	72	104	160	215	276	–	–
8	3	6	10	19	26	42	60	93	125	160	252	–
6	1	4	6	11	15	25	37	56	76	98	154	222
4	1	2	4	7	9	16	22	35	47	60	94	136
3	1	1	3	6	8	13	19	29	39	51	80	116
2	1	1	3	5	7	11	16	25	33	43	67	97
1	1	1	1	3	5	8	12	18	25	32	50	72
0	–	1	1	3	4	7	10	15	21	27	42	61
00	–	1	1	2	3	6	8	13	17	22	35	51
000	–	1	1	1	3	5	7	11	14	18	29	42
0000	–	–	1	1	2	4	6	9	12	15	24	35
250	–	–	1	1	1	3	4	7	9	12	20	28
300	–	–	1	1	1	3	4	6	8	11	17	24
350	–	–	–	1	1	2	3	5	7	9	15	21
400	–	–	–	1	1	1	3	5	6	8	13	19
500	–	–	–	1	1	1	2	4	5	7	11	16

*Type FEPB sizes AWG No. 14-8 inclusive. Use Table 1 for FEPB sizes larger than AWG No. 8.

Table 2. Trade Sizes of Conduit or Tubing for Number of Conductors

Lead-Covered Types RL and RHL—600 V.

(See Sections 346-6 and 348-6)

Size AWG MCM	Number of Single Conductor Cables				Number of 2-Conductor Cables				Number of 3-Conductor Cables			
	1	2	3	4	1	2	3	4	1	2	3	4
14	½	¾	¾	1	¾	1	1	1¼	¾	1¼	1½	1½
12	½	¾	¾	1	¾	1	1¼	1¼	1	1¼	1½	2
10	½	¾	1	1	¾	1¼	1¼	1½	1	1½	2	2
8	½	1	1¼	1½	1	1¼	1½	2	1	2	2	2½
6	¾	1¼	1½	1½	1¼	1½	2	2½	1¼	2½	3	3
4	¾	1¼	1½	1½	1¼	2	2½	2½	1½	3	3	3½
3	¾	1¼	1½	2	1¼	2	2½	3	1½	3	3	3½
2	1	1¼	1½	2	1¼	2	2½	3	1½	3	3½	4
1	1	1½	2	2	1½	2½	3	3½	2	3½	4	5
0	1	2	2	2½	2	2½	3	3½	2	4	5	5
00	1	2	2	2½	2	3	3½	4	2½	4	5	5
000	1¼	2	2½	2½	2	3	3½	4	2½	5	5	6
0000	1¼	2½	2½	3	2½	3	3½	5	3	5	6	6
250	1¼	2½	3	3	...	...	...	...	3	6	6	...
300	1½	3	3	3½	...	...	...	...	3½	6	6	...
350	1½	3	3	3½	...	...	...	...	3½	6	6	...
400	1½	3	3	3½	...	...	...	...	3½	6	6	...
500	1½	3	3½	4	...	...	...	...	4	6	...	...
600	2	3½	4	5	...	...	...	...	...	...	...	...
700	2	4	4	5	...	...	...	...	...	...	...	...
750	2	4	4	5	...	...	...	...	...	...	...	...
800	2	4	5	5	...	...	...	...	...	...	...	...
900	2½	4	5	5	...	...	...	...	...	...	...	...
1000	2½	5	5	6	...	...	...	...	...	...	...	...
1250	3	5	5	6	...	...	...	...	...	...	...	...
1500	3	5	6	6	...	...	...	...	...	...	...	...
1750	3	6	6	...	...	...	...	...	...	...	...	...
2000	3½	6	6	...	...	...	...	...	...	...	...	...

The above sizes apply to straight runs or with nominal offsets equivalent to not more than two quarter-bends.

See Section 346-10 for bends in conduit.

Table 3. Combination of Conductors

(See Sections 346-6, 346-11 and 348-6)

For groups or combinations of conductors not included in Table 1, Chapter 9, for new work, or Tables 1, 1A or 1B Chapter 9, for rewiring, the conduit or tubing shall be of such size that the sum of the cross-sectional areas of the individual conductors will not be more than the percentage of the interior cross-sectional area of the conduit or tubing shown in the following table:

Per Cent Area of Conduit or Tubing

	Number of Conductors				
	1	2	3	4	Over 4
Conductors (not lead covered)	53	31	40	40	40
Lead-covered conductors	55	30	40	38	35

For ampacity of more than three conductors in a conduit or tubing, see Tables 310-12 through 310-15, Note 8.

See Tables 4 through 8, Chapter 9, for dimensions of conductors, conduit and tubing.

Tables 4 through 8, Chapter 9. Tables 4 through 8 give the nominal size of conductors and conduit or tubing recommended for use in computing size of conduit or tubing for various combinations of conductors. The dimensions represent average conditions only, and while variations will be found in dimensions of conductors and conduits of different manufacture, these variations will not affect the computation.

Table 4. Dimensions and Per Cent Area of Conduit and of Tubing

Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 3, Chapter 9.

Trade Size	Internal Diameter Inches	Area—Square Inches								
		Total 100%	Not Lead Covered			Lead Covered				
			1 Cond. 53%	2 Cond. 31%	3 Cond. and Over 40%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%
½	.622	.30	.16	.09	.12	.17	.09	.12	.11	.11
¾	.824	.53	.28	.16	.21	.29	.16	.21	.20	.19
1	1.049	.86	.46	.27	.34	.47	.26	.34	.33	.30
1¼	1.380	1.50	.80	.47	.60	.83	.45	.60	.57	.53
1½	1.610	2.04	1.08	.63	.82	1.12	.61	.82	.78	.71
2	2.067	3.36	1.78	1.04	1.34	1.85	1.01	1.34	1.28	1.18
2½	2.469	4.79	2.54	1.48	1.92	2.63	1.44	1.92	1.82	1.68
3	3.068	7.38	3.91	2.29	2.95	4.06	2.21	2.95	2.80	2.58
3½	3.548	9.90	5.25	3.07	3.96	5.44	2.97	3.96	3.76	3.47
4	4.026	12.72	6.74	3.94	5.09	7.00	3.82	5.09	4.83	4.45
5	5.047	20.00	10.60	6.20	8.00	11.00	6.00	8.00	7.60	7.00
6	6.065	28.89	15.31	8.96	11.56	15.89	8.67	11.56	10.98	10.11

Table 5. Dimensions of Rubber-Covered and Thermoplastic-Covered Conductors

	Types RF-2, RFH-2 R, RH, RHH*** RHW,*** RH-RW, RW		Types TF, T, THW,† TW, RU,** RUH,** RUW**		Types THHN, THWN		Types FEP, FEPB	
Size AWG MCM	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. In.	Approx. Diam. Inches	Approx. Area Sq. Inches
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9
18	.146	.0167	.106	.0088	...	....	...	....
16	.158	.0196	.118	.0109	...	....	...	....
14	2/64 in. .171	.0230	.131	.0135	.105	.0087	.105 .105	.0087 .0087
14	3/64 in. .204*	.0327*	...	....	...	....	... ...	....
14	....	....	.162†	.0206†	...	....	... ...	....
12	2/64 in. .188	.0278	.148	.0172	.122	.0117	.121 .121	.0115 .0115
12	3/64 in. .221*	.0384*	...	....	...	....	... ...	....
12	....	....	.179†	.0251†	...	....	... ...	....
10	...... .242	.0460	.168	.0224	.153	.0184	.142 .142	.0159 .0159
10	....	....	.199†	.0311†	...	....	... ...	....
8	...... .311	.0760	.228	.0408	.201	.0317	.189 .169	.0280 .0225
8	....	....	.259†	.0526†	...	....	... ...	....
6	.397	.1238	.323	.0819	.257	.0519	.244 .302	.0467 .0716
4	.452	.1605	.372	.1087	.328	.0845	.292 .350	.0669 .0962
3	.481	.1817	.401	.1263	.356	.0995	.320 .378	.0803 .1122
2	.513	.2067	.433	.1473	.388	.1182	.352 .410	.0973 .1316
1	.588	.2715	.508	.2027	.450	.1590	...	....
0	.629	.3107	.549	.2367	.491	.1893	...	....
00	.675	.3578	.595	.2781	.537	.2265	...	....
000	.727	.4151	.647	.3288	.588	.2715	...	....
0000	.785	.4840	.705	.3904	.646	.3278	...	....
250	.868	.5917	.788	.4877	.716	.4026	...	....
300	.933	.6837	.843	.5581	.771	.4669	...	....
350	.985	.7620	.895	.6291	.822	.5307	...	....
400	1.032	.8365	.942	.6969	.869	.5931	...	....
500	1.119	.9834	1.029	.8316	.955	.7163	...	....
600	1.233	1.1940	1.143	1.0261	...	....	...	....
700	1.304	1.3355	1.214	1.1575	...	....	...	....
750	1.339	1.4082	1.249	1.2252	...	....	...	.....
800	1.372	1.4784	1.282	1.2908	...	....	...	....
900	1.435	1.6173	1.345	1.4208	...	....	...	....
1000	1.494	1.7531	1.404	1.5482	...	....	...	....
1250	1.676	2.2062	1.577	1.9532	...	....	...	....
1500	1.801	2.5475	1.702	2.2748	...	....	...	....
1750	1.916	2.8895	1.817	2.5930	...	....	...	....
2000	2.021	3.2079	1.922	2.9013	...	....	...	....

* The dimensions of Types RHH, RH-RW, RHW, and RW wire. Also, these dimensions to be used for new work in computing size of conduit or tubing for combinations of wires not shown in Table 1, Chapter 9.

** No. 14 to No. 2:

† Dimensions of THW wire in sizes 14 to 8. No. 6 THW wire and larger is the same dimension as T wire.

*** Dimensions of RHH and RHW without outer covering are the same as THW.

No. 18 to No. 8, solid; No. 6 and larger, stranded.

The dimensions of rubber-covered conductors in Column 3 of this Table are to be used in computing the size of conduit or tubing for new work for combinations not shown in Table 1. For rewiring existing raceways, the areas in columns 3, 5, 7 or 9 are to be used.

Table 6. Dimensions of Lead-Covered Conductors

Types RL, RHL, and RUL

Size AWG-MCM	Single Conductor		Two Conductor		Three Conductor	
	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.	Diam. Inches	Area Sq. Ins.
14	.28	.062	.28 x .47	.115	.59	.273
12	.29	.066	.31 x .54	.146	.62	.301
10	.35	.096	.35 x .59	.180	.68	.363
8	.41	.132	.41 x .71	.255	.82	.528
6	.49	.188	.49 x .86	.369	.97	.738
4	.55	.237	.54 x .96	.457	1.08	.916
2	.60	.283	.61 x 1.08	.578	1.21	1.146
1	.67	.352	.70 x 1.23	.756	1.38	1.49
0	.71	.396	.74 x 1.32	.859	1.47	1.70
00	.76	.454	.79 x 1.41	.980	1.57	1.94
000	.81	.515	.84 x 1.52	1.123	1.69	2.24
0000	.87	.593	.90 x 1.64	1.302	1.85	2.68
250	.98	.754	....	.....	2.02	3.20
300	1.04	.85	....	.....	2.15	3.62
350	1.10	.95	....	.....	2.26	4.02
400	1.14	1.02	....	.....	2.40	4.52
500	1.23	1.18	....	.....	2.59	5.28

Note — No. 14 to No. 8, solid conductors: No. 6 and larger, stranded conductors. Data for 2/64-inch insulation not yet compiled.

Table 7. Dimensions of Asbestos-Varnished-Cambric Insulated Conductors

Types AVA, AVB, and AVL

Size AWG MCM	Type AVA		Type AVB		Type AVL	
	Approx. Diam. Inches	Approx. Area Sq. Ins.	Approx. Diam. Inches	Approx. Area Sq. Ins.	Approx. Diam. Inches	Approx. Area Sq. Ins.
14	.245	.047	.205	.033	.320	.080
12	.265	.055	.225	.040	.340	.091
10	.285	.064	.245	.047	.360	.102
8	.310	.075	.270	.057	.390	.119
6	.395	.122	.345	.094	.430	.145
4	.445	.155	.395	.123	.480	.181
2	.505	.200	.460	.166	.570	.255
1	.585	.268	.540	.229	.620	.300
0	.625	.307	.580	.264	.660	.341
00	.670	.353	.625	.307	.705	.390
000	.720	.406	.675	.358	.755	.447
0000	.780	.478	.735	.425	.815	.521
250	.885	.616	.855	.572	.955	.715
300	.940	.692	.910	.649	1.010	.800
350	.995	.778	.965	.731	1.060	.885
400	1.040	.850	1.010	.800	1.105	.960
500	1.125	.995	1.095	.945	1.190	1.118
550	1.165	1.065	1.135	1.01	1.265	1.26
600	1.205	1.140	1.175	1.09	1.305	1.34
650	1.240	1.21	1.210	1.15	1.340	1.41
700	1.275	1.28	1.245	1.22	1.375	1.49
750	1.310	1.35	1.280	1.29	1.410	1.57
800	1.345	1.42	1.315	1.36	1.440	1.63
850	1.375	1.49	1.345	1.43	1.470	1.70
900	1.405	1.55	1.375	1.49	1.505	1.78
950	1.435	1.62	1.405	1.55	1.535	1.85
1000	1.465	1.69	1.435	1.62	1.565	1.93

Note: No. 14 to No. 8, solid, No. 6 and larger, stranded; except AVL where all sizes are stranded.

Varnished-Cambric Insulated Conductors
Type V

The insulation thickness for varnished-cambric conductors, Type V, is the same as for rubber-covered conductors, Type RH, except for Nos. 14 and 12 which have 3/64-inch insulation for varnished-cambric and 2/64-inch insulation for rubber-covered conductors and for No. 8 which has 3/64-inch insulation for varnished-cambric, and 4/64-inch insulation for rubber-covered conductors. See Table 310-2(b). Tables 1 and 2 may, therefore, be used for the number of varnished-cambric insulated conductors in a conduit or tubing.

Table 8. Properties of Conductors

		Concentric Lay Stranded Conductors		Bare Conductors		D. C. Resistance Ohms/ M Ft. At 25°C. 77°F.		
						Copper		Aluminum
Size AWG MCM	Area Cir. Mils	No. Wires	Diam. Each Wire Inches	Diam. Inches	*Area Sq. Inches	Bare Cond.	Tin'd. Cond.	
18	1624	Solid	.0403	.0403	.0013	6.51	6.79	10.7
16	2583	Solid	.0508	.0508	.0020	4.10	4.26	6.72
14	4107	Solid	.0641	.0641	.0032	2.57	2.68	4.22
12	6530	Solid	.0808	.0808	.0051	1.62	1.68	2.66
10	10380	Solid	.1019	.1019	.0081	1.018	1.06	1.67
8	16510	Solid	.1285	.1285	.0130	.6404	.659	1.05
6	26250	7	.0612	.184	.027	.410	.427	.674
4	41740	7	.0772	.232	.042	.259	.269	.424
3	52640	7	.0867	.260	.053	.205	.213	.336
2	66370	7	.0974	.292	.067	.162	.169	.266
1	83690	19	.0664	.332	.087	.129	.134	.211
0	105500	19	.0745	.373	.109	.102	.106	.168
00	133100	19	.0837	.418	.137	.0811	.0843	.133
000	167800	19	.0940	.470	.173	.0642	.0668	.105
0000	211600	19	.1055	.528	.219	.0509	.0525	.0836
250	250000	37	.0822	.575	.260	.0431	.0449	.0708
300	300000	37	.0900	.630	.312	.0360	.0374	.0590
350	350000	37	.0973	.681	.364	.0308	.0320	.0505
400	400000	37	.1040	.728	.416	.0270	.0278	.0442
500	500000	37	.1162	.814	.520	.0216	.0222	.0354
600	600000	61	.0992	.893	.626	.0180	.0187	.0295
700	700000	61	.1071	.964	.730	.0154	.0159	.0253
750	750000	61	.1109	.998	.782	.0144	.0148	.0236
800	800000	61	.1145	1.031	.835	.0135	.0139	.0221
900	900000	61	.1215	1.093	.938	.0120	.0123	.0197
1000	1000000	61	.1280	1.152	1.042	.0108	.0111	.0177
1250	1250000	91	.1172	1.289	1.305	.00863	.00888	.0142
1500	1500000	91	.1284	1.412	1.566	.00719	.00740	.0118
1750	1750000	127	.1174	1.526	1.829	.00616	.00634	.0101
2000	2000000	127	.1255	1.631	2.089	.00539	.00555	.00885

* Area given is that of a circle having a diameter equal to the overall diameter of a stranded conductor.

The values given in the table are those given in Circular 31 of the National Bureau of Standards except that those shown in the 8th column are those given in Specification B33 of the American Society for Testing and Materials.

The resistance values given in the last three columns are applicable only to direct current. When conductors larger than No. 4/0 are used with alternating current the multiplying factors in Table 9, Chapter 9 should be used to compensate for skin effect.

Table 9. Multiplying Factors for Converting D.C. Resistance to 60 Cycle A.C. Resistance

Size	Multiplying Factor			
	For Nonmetallic Sheathed Cables in Air or Nonmetallic Conduit		For Metallic Sheathed Cables or all Cables in Metallic Raceways	
	Copper	Aluminum	Copper	Aluminum
Up to 3 AWG	1.	1.	1.	1.
2	1.	1.	1.01	1.00
1	1.	1.	1.01	1.00
0	1.001	1.000	1.02	1.00
00	1.001	1.001	1.03	1.00
000	1.002	1.001	1.04	1.01
0000	1.004	1.002	1.05	1.01
250 MCM	1.005	1.002	1.06	1.02
300 MCM	1.006	1.003	1.07	1.02
350 MCM	1.009	1.004	1.08	1.03
400 MCM	1.011	1.005	1.10	1.04
500 MCM	1.018	1.007	1.13	1.06
600 MCM	1.025	1.010	1.16	1.08
700 MCM	1.034	1.013	1.19	1.11
750 MCM	1.039	1.015	1.21	1.12
800 MCM	1.044	1.017	1.22	1.14
1000 MCM	1.067	1.026	1.30	1.19
1250 MCM	1.102	1.040	1.41	1.27
1500 MCM	1.142	1.058	1.53	1.36
1750 MCM	1.185	1.079	1.67	1.46
2000 MCM	1.233	1.100	1.82	1.56

B. Examples

Selection of Conductors. In the following examples, the size of conductor has been selected on the basis of the allowable ampacities tabulated in the second column of Table 310-12. If other types of insulated conductors are used, or if the conductors are run open, or with more than three conductors in a raceway, the size of conductor may vary from those shown. Tables 310-12 through 310-15 and Notes thereto should be consulted in selecting the size of conductor for a particular installation.

Voltage. For uniform application of the provisions of Articles 210, 215 and 220 a nominal voltage of 115 and 230 volts shall be used in computing the ampere load on the conductor.

Fractions of an Ampere. Where the computations result in a fraction of an ampere, such fractions may be dropped.

Ranges. For the computation of the range loads in these examples Column A of Table 220-5 has been used. For optional methods, see Columns B and C of Table 220-5.

Example No. 1. Single Family Dwelling

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic, and open porches. It has a 12 kw range.

Computed Load (see Section 220-4)
  General Lighting Load:
    1500 sq. ft. at 3 watts per sq. ft. = 4500 watts.

Minimum Number of Branch Circuits Required (see Section 220-3)
  General Lighting Load:
    4500 ÷ 115 = 39.1 amperes; or three 15 ampere 2-wire circuits; or two 20 ampere 2-wire circuits
  Small Appliance Load: Two 2-wire 20 ampere circuits (Section 220-3(b))

Minimum Size Feeders Required (see Section 220-4)
  Computed Load

General Lighting	4500 watts
Small Appl. Load	3000 watts
Total (without range)	7500 watts
3000 watts at 100%	3000 watts
7500 — 3000 = 4500 watts at 35% =	1575 watts
Net computed (without range)	4575 watts
Range Load (see Table 220-5)	8000 watts
Net computed (with range)	12,575 watts

For 115/230 volt 3-wire system feeders, 12,575 ÷ 230 = 55 amperes

Therefore, feeder size for total load may be selected on basis of 55 ampere load (see Section 215-2)

Net computed load exceeds 10 kw. so service conductors shall be 100 amperes (see Section 230-41 Exception No. 1).

Example No. 1(a). Single Family Dwelling

Same conditions as Example No. 1, plus addition of one 6 ampere 230 volt room air conditioning unit and three 12 ampere 115 volt room air conditioning units. See Article 422, Part F.

From Example No. 1, feeder current is 55 amperes (3 wire, 230 volt)

Line A	Neutral	Line B	
55		55	amperes from Example No. 1
6		6	one 230 volt air cond. motor
12		12	two 115 volt air cond. motors
—		12	one 115 volt air cond. motor
3		3	25% of largest motor (Section 430-24)
76		88	amperes per line

Therefore, feeder size for total load may be selected on basis of 88 ampere load. For feeder overcurrent protection see Sections 215-4 and 430-63.

Example No. 1(b). Single Family Dwelling.

Optional Calculation for One-Family Dwelling (Section 220-7)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has a 12 kw range, a 2.5 kw water heater, a 1.2 kw dishwasher, 9 kw of electric space heating installed in five rooms, a 4.5 kw clothes dryer, and a 6 amp. 230 volt room air conditioning unit.

Air conditioner kw is 6 × 230 ÷ 1000 = 1.38 kw

1.38 kw is less than the connected load of 9 kw of space heating; therefore, the air conditioner load need not be included in the service calculation (see Section 220-4(k)).

1500 sq. ft. at 3 watts	4.5 kw
Two 20 amp. appliance outlet circuits at 1500 watts each	3.0 kw
Range (at nameplate rating)	12.0 kw
Water heater	2.5 kw
Dishwasher	1.2 kw
Space heating	9.0 kw
Clothes dryer	4.5 kw
	36.7 kw

First 10 kw at 100% = 10.00 kw

Remainder at 40% (26.7 kw × .4) = 10.68 kw

Calculated load for service size. 20.68 kw = 20,680 watts

20,680 ÷ 230 = 90 amperes

Therefore, this dwelling may be served by a 100 ampere service.

Example No. 1(c). Single Family Dwelling.

Optional Calculation for One-Family Dwelling (See Section 220-7)

Dwelling has a floor area of 1500 sq. ft. exclusive of unoccupied cellar, unfinished attic and open porches. It has 3 - 20 ampere small appliance circuits, two 4 kw wall-mounted ovens, one 5.1 kw counter-mounted cooking unit, a 4.5 kw water heater, a 1.2 kw dishwasher, a 4.2 kw combination clothes washer and dryer, 6 - 7 ampere 230 volt room air conditioning units and a 1.5 kw permanently installed bathroom space heater.

Air conditioning kw calculation

Total amperes 6 × 7 = 42.00 amperes
25% of largest motor .25 × 7 = 1.75 amperes

43.75 amperes

43.75 × 230 ÷ 1000 = 10.1 kw of air conditioner load

Load included at 100%

Air conditioning		10.1 kw
Space heater (omit, see Section 220-4(k))		

Other Load

1500 sq. ft. at 3 watts	4.5	
Three 20 amp small appliance circuits at 1500 watts	4.5	
2 ovens	8.	
1 cooking unit	5.1	
Water heater	4.5	
Dishwasher	1.2	
Washer/Dryer	4.2	
Total other load	32.0	
1st 10 kw at 100%		10.0 kw
Remainder at 40% (22 kw × .4)		8.8 kw
Total calculated load		28.9 kw = 28,900 watts

28,900 ÷ 230 = 126 amperes (service rating)

Example No. 2. Small Roadside Fruitstand With No Show Windows

A small roadside fruitstand with no show windows has a floor area of 150 square feet. The electrical load consists of general lighting and a 1000 watt floodlight. There are no other outlets.

Computed Load (Section 220-4)

*General Lighting

150 sq. ft. at 3 watts/sq. ft. × 1.25 = 562 watts

(3 watts/sq. ft. for stores)

562 watts ÷ 115 = 4.88 amperes

One 15 ampere 2 wire branch circuit required (Section 220-3)

(Example 2 Continued Next Page)

Example No. 2 (Continued)

Minimum Size Service Conductor Required (Section 230-41 Exception No. 2)

Computed load	562 watts
Floodlight load	1000 watts
Total load	1562 watts

1562 ÷ 115 = 13.6 amperes

Use No. 8 service conductor (Section 230-41 Exception No. 2)
Use a 30 ampere service switch or breaker (Section 230-71)

Example No. 3. Store Building

A store 50 feet by 60 feet, or 3,000 square feet, has 30 feet of show window.

Computed Load (Section 220-4)

*General lighting load:	
3,000 square feet at 3 watts per square foot × 1.25	11,250 watts
**Show window lighting load:	
30 feet at 200 watts per foot	6,000 watts

Minimum Number of Branch Circuits Required (Section 220-3)

***General lighting load: 11,250 ÷ 230 = 49 amperes for 3 wire, 115/230 volts; or 98 amperes for 2 wire, 115 volts:

Three 30 ampere, 2-wire; and one 15 ampere, 2-wire ciruits; or
Five 20 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire, and three 15 ampere, 2-wire circuits; or
Seven 15 ampere, 2-wire, circuits; or
Three 15 ampere, 3-wire, and one 15 ampere, 2-wire circuits.

Special lighting load (show window): (Sections 220-2 Exception No. 2 and 220-4(b)): 6,000 ÷ 230 = 26 amperes for 3-wire, 115/230 volts; or 52 amperes for 2-wire, 115 volts:

Four 15 ampere, 2-wire circuits; or
Three 20 ampere, 2-wire circuits; or
Two 15 ampere, 3-wire circuits.

Minimum Size Feeders (or Service Conductors) Required (Section 215-2):

For 115/230 volt, 3-wire system:
Ampere load: 49 plus 26 = 75 amperes. (Section 220-2):
Size of each feeder, No. 3

For 115 volt system:
Ampere load: 98 plus 52 = 150 amperes. (Section 220-2):
Size of each feeder, No. 3/0

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*The above examples assume that the entire general lighting load is likely to be used for long periods of time and the load is therefore increased by 25 per cent in accordance with Section 220-2. The 25 per cent increase is not applicable to any portion of the load not used for long periods.

**If show window load computed as per Section 220-2, the unit load per outlet to be increased 25 per cent.

*** The load on each general lighting branch circuit not to exceed 80% of the branch circuit rating (Section 210-23b).

Example No. 4. Multi-Family Dwelling

Multi-family dwelling having a total floor area of 32,000 square feet with 40 apartments.

Meters in two banks of 20 each and individual sub-feeders to each apartment.

One-half of the apartments are equipped with electric ranges of not exceeding 12 kw each.

Area of each apartment is 800 square feet.

Computed Load for Each Apartment (Article 220):

General lighting load:	
800 square feet at 3 watts per square foot	2,400 watts
Special appliance load:	
Electric range	8,000 watts

Minimum Number of Branch Circuits Required for Each Apartment (Section 220-3):

General lighting load: 2,400 ÷ 115 = 21 amperes or two 15 ampere, 2-wire circuits; or two 20 ampere, 2-wire circuits.

Small appliance load: Two 2-wire circuits of No. 12 wire. (See Section 220-3(b)).

Range Circuit: 8,000 ÷ 230 = 34 amperes or a circuit of two No. 8's and one No. 10 as permitted by Section 210-19(c).

Minimum Size Sub-Feeder Required for Each Apartment (Section 215-2):

Computed load (Article 220):	
General lighting load	2,400 watts
Small appliance load, two 20 ampere circuits	3,000 watts
Total computed load (without ranges)	5,400 watts
Application of Demand Factor:	
3,000 watts at 100 %	3,000 watts
2,400 watts at 35%	840 watts
Net computed load (without ranges)	3,840 watts
Range load	8,000 watts
Net computed load (with ranges)	11,840 watts

For 115/230 volt, 3 wire system (without ranges):
Net computed load, 3,840 ÷ 230 = 16.7 amperes.
Size of each sub-feeder (see Section 215-2).

For 115/230 volt, 3 wire system (with ranges):
Net computed load, 11,840 ÷ 230 = 51.5 amperes.
Size of each ungrounded sub-feeder, No. 6.

Neutral Sub-Feeder:	
Lighting and small appliance load	3,840 watts
Range load, 8,000 watts at 70% (see Section 220-4(d))	5,600 watts
Net computed load (neutral)	9,440 watts

9,440 ÷ 230 = 41 amperes
Size of neutral sub feeder, No. 6

(Example 4 Continued Next Page)

Example No. 4 (Continued)

Minimum Size Feeders Required from Service Equipment to Meter Bank
(For 20 Apartments—10 with Ranges):

Total Computed Load:
Lighting and small appliance load, 20 × 5,400 .... 108,000 watts
Application of Demand Factor:
3,000 watts at 100% .... 3,000 watts
105,000 watts at 35% .... 36,750 watts
Net computed lighting and small appliance load .... 39,750 watts
Range load, 10 ranges (less than 12 kw; Col. A, Table 220-5) .... 25,000 watts
Net computed load (with ranges) .... 64,750 watts
For 115/230 volt, 3 wire system:
Net computed load, 64,750 ÷ 230 = 282 amperes.
Size of each ungrounded feeder to each meter bank: 500,000 c.m.
Neutral Feeder:
Lighting and small appliance load .... 39,750 watts
Range load: 25,000 watts at 70% (see Section 220-4(d)) 17,500 watts

Computed load (neutral) .... 57,250 watts
57,250 ÷ 230 = 249 amperes.
Further Demand Factor (Section 220-4(d)):
200 amperes at 100% = 200 amperes
49 amperes at 70% = 34 amperes

Net computed load (neutral) .... 234 amperes
Size of neutral feeder to each meter bank: 300,000 c.m.

Minimum Size Main Feeder (or Service Conductors) Required
(For 40 Apartments—20 with Ranges):

Total Computed Load:
Lighting and small appliance load, 40 × 5,400 .... 216,000 watts
Application of Demand Factor:
3,000 watts at 100% .... 3,000 watts
117,000 watts at 35% .... 40,950 watts
96,000 watts at 25% .... 24,000 watts

Net computed lighting and small appliance load .... 67,950 watts
Range load, 20 ranges (less than 12 kw, Col. A, Table 220-5) .... 35,000 watts
Net computed load .... 102,950 watts
For 115/230 volt, 3 wire system:
Net computed load, 102,950 ÷ 230 = 448 amperes.
Size of each ungrounded main feeder: 1,000,000 c.m.
Neutral Feeder:
Lighting and small appliance load .... 67,950 watts
Range load, 35,000 watts at 70% (see Section 220-4(d)) 24,500 watts

Computed load (neutral) .... 92,450 watts
92,450 ÷ 230 = 402 amperes.
Further Demand Factor (see Section 220-4(d)):
200 amperes at 100% = 200 amperes
202 amperes at 70% = 141 ampere

Net computed load (neutral) .... 341 ampere
Size of neutral main feeder: 600,000 c.m.
See Tables 310-12 through 310-15, Notes 8 and 12.

Example No. 5. Calculation of Neutral Feeder

(See Section 220-4)

The following example illustrates the method of calculating size of neutral feeder for the computed load of a 5-wire, 2-phase system, where it is desired to modify the load in accordance with provisions of Section 220-4.

An installation consisting of a computed load of 250 amperes connected between neutral feeder and each ungrounded feeder.

Neutral Feeder (maximum unbalance of load 250 amp. × 140% = 350 amperes):
200 amperes (first) at 100% = 200 amperes
150 amperes (excess) at 70% = 105 amperes

Computed load 305 amperes
Size of neutral feeder: 500,000 c.m.

Example No. 6. Maximum Demand for Range Loads

Table 220-5, Column A applies to ranges not over 12 kw. The application of Note 1 to ranges over 12 kw (and not over 27 kw) is illustrated in the following examples:

A. Ranges all of same rating.
Assume 24 ranges each rated 16 kw.
From Column A the maximum demand for 24 ranges of 12 kw rating is 39 kw.
16 kw exceeds 12 kw by 4.
5% × 4 = 20% (5% increase for each kw in excess of 12).
39 kw × 20% = 7.8 kw increase.
39 + 7.8 = 46.8 kw: value to be used in selection of feeders.

B. Ranges of unequal rating.
Assume 5 ranges each rated 11 kw.
2 ranges each rated 12 kw.
20 ranges each rated 13.5 kw.
3 ranges each rated 18 kw.
5 × 12 = 60 Use 12 kw for range rated less than 12.
2 × 12 = 24
20 × 13.5 = 270
3 × 18 = 54

408 kw
408 ÷ 30 = 13.6 kw (average to be used for computation)
From Column A the demand for 30 ranges of 12 kw rating is 15 + 30 = 45 kw.
13.6 exceeds 12 by 1.6 (use 2.).
5% × 2 = 10% (5% increase for each kw in excess of 12).
45 kw × 10% = 4.5 kw increase.
45 + 4.5 = 49.5 kw = value to be used in selection of feeders.

Example No. 7. Ranges on a 3-Phase System

(Section 220-4(d))

Thirty ranges rated at 12 kw each are supplied by a 3-phase, 4-wire, 120/208-volt feeder, 10 ranges on each phase.

As there are 20 ranges connected to each ungrounded conductor, the load should be calculated on the basis of 20 ranges (or in case of unbalance, twice the maximum number between any two phase wires)

since diversity applies only to the number of ranges connected to adjacent phases and not the total.

The current in any one conductor will be one-half the total watt load of two adjacent phases divided by the line-to-neutral voltage. In this case, 20 ranges, from Table 220-5, will have a total watt load of 35,000 watts for two phases; therefore, the current in the feeder conductor would be:

$$17{,}500 \div 120 = 146 \text{ amperes.}$$

On a three-phases basis the load would be:

$$3 \times 17{,}500 = 52{,}500 \text{ watts}$$

and the current in each feeder conductor—

$$\frac{52{,}500}{208 \times 1.73} = 146 \text{ amperes}$$

Example No. 8. Motors, Conductors, and Overcurrent Protection
(See Sections 430-22, 430-24, 430-32 and 430-52)

Determine the size of conductors, the motor-running overcurrent protection, the branch circuit protection, and the feeder protection, for one 25-h.p. squirrel-cage induction motor (full-voltage starting), and two 30-h.p. wound-rotor induction motors, on a 440-volt, 3-phase, 60-cycle supply.

Conductor Sizes

The full-load current of the 25-h.p. motor is 32 amperes (Table 430-150). A full-load current of 32 amperes × 1.25 (Section 430-22) requires a No. 8, Type R, rubber-covered conductor (Table 310-12). The full-load current of the 30-h.p. motor is 39 amperes (Table 430-150). A full-load current of 39 amperes × 1.25 (Section 430-22) requires a No. 6, Type R, rubber-covered conductor (Table 310-12).

The feeder conductor capacity will be 125 per cent of 39, plus 39, plus 32, or 120 amperes (Section 430-24). In accordance with Table 310-12, this would require a No. 0, Type R, rubber-covered feeder.

Note. For Type R conductors run open in air, or for conductors with insulations other than Type R, see Tables 310-12 through 310-15.

Overcurrent Protection

Running. The 25-h.p. motor, with full-load current of 32 amperes, must have running overcurrent protection of not over 40 amperes (Columns 2 and 3, Table 430-146). The 30-h.p. motor with full-load current of 39 amperes must have running overcurrent protection of not over 50 amperes (Columns 2 and 3, Table 430-146).

Branch Circuit. The branch circuit of the 25-h.p. motor must have branch-circuit overcurrent protection of not over 100 amperes (Column 4, Table 430-146). The branch circuit of the 30-h.p. motor must have branch-circuit overcurrent protection of not over 60 amperes (Column 7, Table 430-146).

Feeder Circuit. The rating of the branch-circuit fuse for a 25-h.p. squirrel-cage motor is 300 per cent of 32 amperes, or 96 amperes, which necessitates the use of a 100 ampere standard size fuse (Table 430-153); and for a 30-h.p. wound rotor motor is 150 per cent of 39 amperes, or 59 amperes (Table 430-153). The rating of the feeder fuse is, therefore, 100 plus 39 plus 39 which equals 178 amperes, and a 200 ampere fuse is the maximum size which may be used (see Section 430-62).

The setting of a motor-branch-circuit circuit-breaker for a 25-h.p. squirrel-cage motor is 250 per cent of 32 amperes or 80 amperes (Table 430-153); for a 30-h.p. wound-rotor motor is 150 per cent of 39 amperes or 59 amperes (Table 430-153). The maximum setting of a feeder circuit-breaker is 80 + 39 + 39 = 158 amperes (see Section 430-62).

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Where a subject is treated in a Section or a Paragraph in a Section, this Index refers directly to the Section designation, such as 250-91. This advises the reader to look in Section 250-91 or either of its two Paragraphs, 250-91(a) or 250-91(b).

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SPECIAL NOTICE

Tentative Interim Amendment No. 127

ARTICLE 354 — UNDERFLOOR RACEWAYS

Section 354-6. Splices and Taps. *Revise to Read:*
354-6. Splices and Taps. Splices or taps shall be made only in junction boxes.

For purposes of this Section, so-called loop wiring (continuous, unbroken conductor connecting the individual outlets) is not considered to be a splice or tap.

Tentative Interim Amendment No. 128

ARTICLE 210 — BRANCH CIRCUITS

Section 210-21. (b). Receptacles. *Add the following sentence to the first paragraph of the Section:*

Grounding type receptacles which are of a type that reject non-grounding type attachment plugs or which are of the locking type may be used for specific purposes or in special locations.

1966 Massachusetts Electrical Code. (Amendment No. 2 eff. August 29, 1967)

supply side of both the primary and secondary windings of the ballast. Under no condition shall the thermal device permit the case temperature of the ballast to exceed 135° C. (275° F.). Simple reactance type ballast need not be thermally protected.

This requirement shall become effective January 1, 1968.

410-72. Direct-Current Equipment. Fixtures installed on direct-current circuits shall be equipped with auxiliary equipment and resistors especially designed and approved for direct-current operation and the fixtures shall be so marked.

410-73. Voltages—Dwelling Occupancies.

(a) Equipment having an open-circuit voltage of more than 1000 volts shall not be installed in dwelling occupancies.

(b) Equipment having an open-circuit voltage of more than 300 volts shall not be installed in dwelling occupancies unless such equipment is so designed that there shall be no exposed live parts when lamps are being inserted, are in place, or are being removed.

410-74. Fixture Mounting.

(a) **Exposed Ballasts.** Fixtures having exposed ballasts or transformers shall be so installed that such ballasts or tranformers shall not be in contact with combustible material.

(b) **Combustible Low-Density Cellulose Fiberboard.** Where a fixture containing a ballast is to be installed on combustible low-density cellulose fiberboard it shall, where surface mounted:

(1) Be approved for this condition, or

(2) Be spaced not less than 1½ inches from the surface of the fiberboard.

(3) Where such fixtures are partially or wholly recessed, the provisions of Sections 410-62 to 410-70 shall apply.

Combustible low-density cellulose fiberboard is considered to include sheets, panels and tiles which have a density of 20 pounds per cubic foot or less, and which are formed of bonded plant fiber material; but does not include solid or laminated wood, nor fiberboard which has a density in excess of 20 pounds per cubic foot or is an approved material which has been integrally treated with fire retarding chemicals to the degree that the flame spread in any plane of the material will not exceed twenty-five as determined by the method of NFPA No. 255, ASTM Designation E-84 or U.L. No. 723.

410-75. Auxiliary Equipment Not Integral with Fixture.

(a) Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a lighting fixture assembly shall be enclosed in accessible, permanently installed metal cabinets.

(b) Where display cases are not permanently installed, no portion of a secondary circuit may be included in more than a single case.

(c) Ballasts approved for separate mounting and for direct connection to an approved wiring system need not be separately enclosed.

410-76. Auto-Transformers. An auto-transformer which is used as part of a ballast for supplying lighting units and which raises the voltage to more than 300 volts shall be supplied only by a grounded system.

410-77. Switches. Snap switches shall conform to Section 380-14.

Q. Special Provisions for Electric Discharge Lighting Systems of More Than 1,000 Volts

410-78. General.

(a) Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of more than 1,000 volts shall be of a type approved for such service.

(b) The terminal of an electric discharge lamp shall be considered as alive when any lamp terminal is connected to a potential of more than 300 volts.

(c) In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Sections 410-78 to 410-90 inclusive.

For signs and outline lighting, see Article 600.

410-79. Control.

(a) Fixtures or lamp installations shall be controlled either singly or in groups by an externally-operable switch or circuit breaker which shall open all ungrounded primary conductors.

(b) The switch or circuit breaker shall be located within sight of the fixtures or lamps, or it may be located elsewhere if it is provided with means for locking in the open position.

410-80. Lamp Terminals and Lampholders. Parts which must be removed for lamp replacement shall be hinged or fastened by an approved means. Lamps or lampholders or both shall be so designed that there shall be no exposed live parts when lamps are being inserted or are being removed.

410-81. Transformer Ratings. Transformers and ballasts shall have a secondary open-circuit voltage of not more than 15,000 volts with an allowance on test of 1,000 volts additional. The secondary current rating shall be not more than 120 milli-amperes when the open circuit voltage is more than 7500 volts, and not more than 240 milli-amperes when the open circuit voltage is 7500 volts or less.

410-82. Transformer Type. Transformers shall be of an approved enclosed type. Transformers of other than the askarel insulated or dry type shall not be used.

410-83. Transformer Secondary Connections.

(a) The high-voltage windings of transformers shall not be connected in series or in parallel, except that for two transformers, each having one end of its high-voltage winding grounded and connected to the enclosure, the high-voltage windings may be connected in series to form the equivalent of a mid-point grounded transformer.

(b) The grounded ends shall be connected by an insulated conductor not smaller than No. 14 AWG.

410-84. Transformer Locations.

(a) Transformers shall be accessible after installation.

(b) The transformers should be installed as near to the lamps as practicable to keep the secondary conductors as short as possible.

(d) Adjacent areas in which hazardous vapors are not likely to be released such as stock rooms, switchboard rooms and other similar locations, having floors elevated at least 18 inches above adjacent garage floor, or separated therefrom by tight curbs or partitions at least 18 inches high, shall not be classed as hazardous.

511-3. Wiring and Equipment in Hazardous Areas. Within hazardous areas as defined in Section 511-2, wiring and equipment shall conform to applicable provisions of Article 501.

511-4. Sealing. Approved seals conforming to the requirements of Section 501-5 shall be provided, and Section 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous area above the floor if any connections or extensions lead into or through such area.

511-5. Wiring in Spaces Above Hazardous Areas.

(a) All fixed wiring shall be in metallic raceways or shall be Type MI or Type ALS cable. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor, but such raceways shall have no connections leading into or through any hazardous area above the floor. No electrical conductor shall be installed in any cell, header or duct which contains a pipe for steam, water, air, gas, drainage, or other service except electrical.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

(c) For connection of portable lamps, motors or other utilization equipment, flexible cord suitable for the type of service and approved for extra hard usage shall be used.

(d) When a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any utilization equipment supplied.

(e) When a pendant is used to supply a portable lamp or utilization equipment, the female portion of a polarized pin-plug connector or equivalent shall be attached to the lower end of the pendant, and the male portion shall be attached to the cord for the portable. The connector shall be designed to break apart readily in any position, and shall be suspended at a level not less than that specified in Section 511-2. Attachment plug receptacles in fixed position shall be located above the level specified in Section 511-2.

511-6. Equipment Above Hazardous Areas.

(a) Equipment which is less than 12 feet above floor level, and which may produce arcs, sparks or particles of hot metal, such as cutouts, switches, receptacles, charging panels, generators, motors, or other equipment (excluding lamps and lampholders) having make and break or sliding contacts, shall be of totally-enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

(b) Lamps and lampholders for fixed lighting which are located over lanes through which vehicles are commonly driven or which may otherwise be exposed to physical damage, shall be located not less than 12 feet above floor level unless provided with suitable guards or screens.

(c) Portable lamps shall be equipped with handle, lampholder, hook and substantial guard attached to the lampholder or handle. All exterior surfaces which might come in contact with battery terminals, wiring terminals, or other objects shall be of nonconducting material or shall be effectively protected with insulation. Lampholders shall be of unswitched type, and shall not provide means for plug-in of attachment plugs. Outer shell shall be of moulded composition or other material approved for the purpose, and metal-shell, lined lampholders, either of switched or unswitched type, shall not be used. Unless the lamp and its cord are supported or arranged in such a manner that they cannot be used in the hazardous areas classified in Section 511-2, they shall be of a type approved for such hazardous locations.

511-7. Battery-Charging Equipment. Battery chargers and their control equipment, and batteries being charged shall not be located within hazardous areas classified in Section 511-2. Tables, racks, trays, and wiring shall, in addition, conform to the provisions of Article 480.

511-8. Electric Vehicle Charging.

(a) Flexible cords used for charging shall be suitable for the type of service and approved for extra hard usage. Their ampacity shall be adequate for the charging current.

(b) Connectors shall have a rating not less than the ampacity of the cord, and in no case less than 50 amperes.

(c) Connectors shall be so designed and installed that they will break apart readily at any position of the charging cable, and live parts shall be guarded from accidental contact. No connector shall be located within a hazardous area defined in Section 511-2.

(d) Where plugs are provided for direct connection to vehicles, the point of connection shall not be within a hazardous area as defined in Section 511-2, and where the cord is suspended from overhead, it shall be so arranged that the lowest point of sag is at least 6 inches above the floor. Where the vehicle is equipped with an approved plug which will readily pull apart, and where an automatic arrangement is provided to pull both cord and plug beyond the range of physical damage, no additional connector is required in the cable or at the outlet.

ARTICLE 512 — RESIDENTIAL STORAGE GARAGES

512-1. Definition. A residential storage garage is a building or room in which not more than three vehicles of the types described in Section 511-1 are or may be stored, but which will not normally be used for other than minor service or repair operations on such stored vehicles.

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By: John W. Rose
Assistant Attorney General

A true copy, Attest:

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EDWARD B. CALLAHAN
Member, Head of a Fire
Department.

Received in accordance with the provisions of G.L. (Ter. Ed. as amended) C. 143, S. 3L; C. 148, S. 10.

August 23, 1967
Leo L. Laughlin
LEO L. LAUGHLIN
Commissioner of Public Safety

Deposited with the Secretary of the Commonwealth on August 29, 1967 in accordance with the provisions of G.L. (Ter. Ed. as amended) C. 143, S. 3L; C. 148, S. 10; C. 30, S. 37; C. 30A, S. 5.

Leo L. Laughlin
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Commissioner of Public Safety

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AUG 29 1967
SECRETARY'S OFFICE

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC SAFETY
BOARD OF FIRE PREVENTION REGULATIONS
1010 Commonwealth Avenue
Boston, Massachusetts 02215

August 29, 1967

As the result of a public hearing, held in accordance with the provisions of Chapter 22, Section 14; Chapter 148, S. 9 and 10; Chapter 143, Section 3L; and Chapter 30A of the Massachusetts General Laws, on July 13, 1967, the Massachusetts Electrical Code, FPR-11, was amended to read as follows:

ARTICLE 410.71 (e)

Fluorescent fixtures for indoor installations shall have an approved thermally actuated protective device integral with the ballast. Such thermal unit shall be installed so as to interrupt the line current on the supply side of both the primary and secondary windings of the ballast. Under no condition shall the thermal device permit the case temperature of the ballast to exceed 135° C. (275° F.). Simple reactance type ballast need not be thermally protected.

This requirement shall become effective January 1, 1968.

ARTICLE 511-6 (b)

(b) Lamps and lampholders for fixed lighting which are located over lanes through which vehicles are commonly driven or which may otherwise be exposed to physical damage, shall be located not less than 12 feet above floor level unless provided with suitable guards or screens.

BOARD OF FIRE PREVENTION REGULATIONS

Samuel Gronich

By: Samuel Gronich
Chairman.

WFF

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JOSEPH MANNIX
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Approved as to matters of form:

EDWARD W. BROOKE

By: John W Wright
Assistant Attorney General

A true copy, Attest:

Leo L. Laughlin
LEO L. LAUGHLIN
Commissioner of Public Safety

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Received in accordance with the provisions of G.L. (Ter. Ed. as amended) C. 143, S. 3L; C.148, s.10
November 15, 1966

Leo L. Laughlin
LEO L. LAUGHLIN
Commissioner of Public Safety

Deposited with the Secretary of the Commonwealth on November 17, 1966, in accordance with the provisions of G.L. (Ter. Ed. as amended) C. 143, S. 3L; C.148 s.10 C. 30, S. 37; and C. 30-A, S. 5.

Leo L. Laughlin
LEO L. LAUGHLIN
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Insert No. 3

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